HOW EDWIN HUBBLE EXPANDED THE UNIVERSE

Astronomy®

HDG 08070

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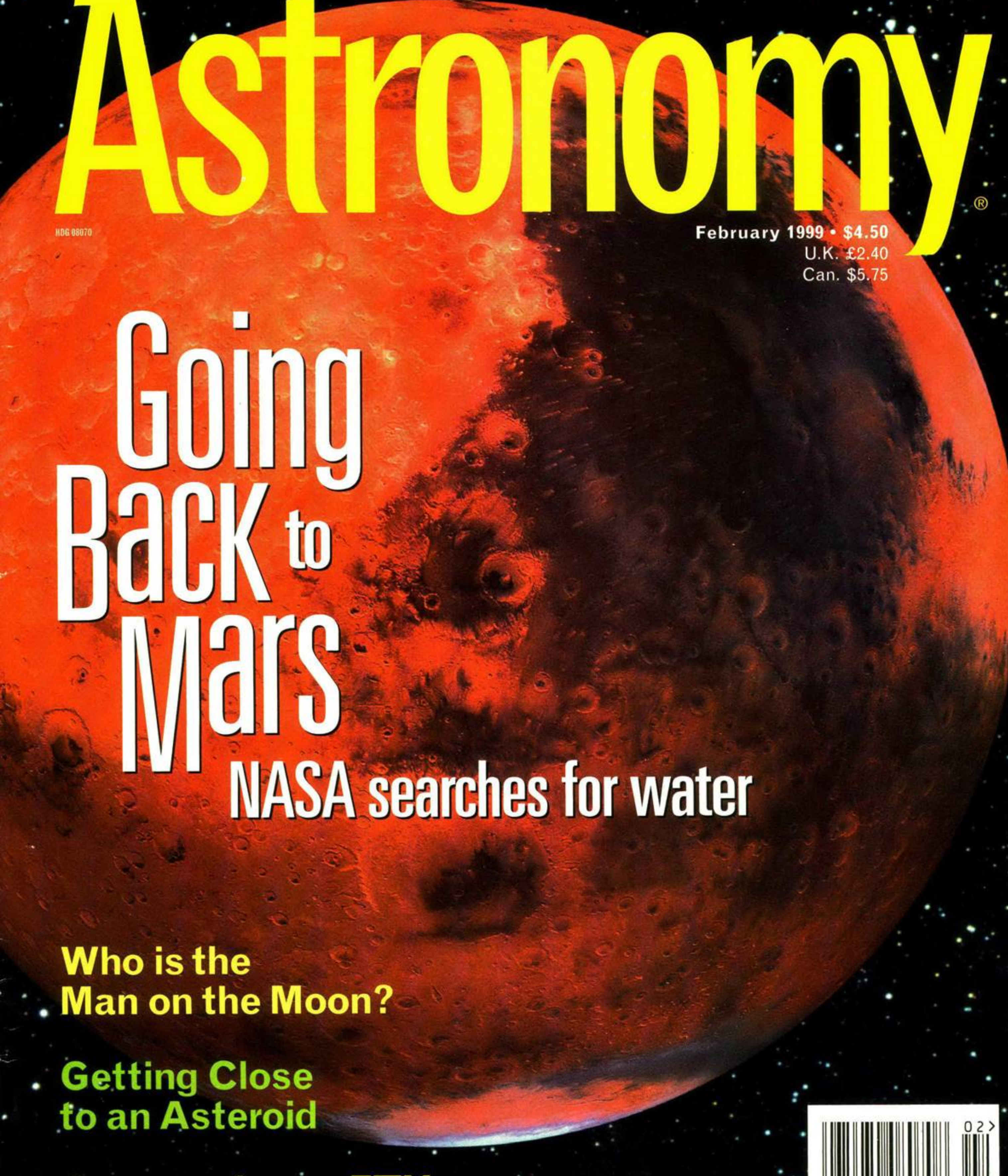

Going Back to Mars

NASA searches for water

Who is the Man on the Moon?

Getting Close to an Asteroid

Accessorize an ETX scope

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LXD 300

Now you can buy a Meade® 8" f/10 Schmidt-Cassegrain Telescope, complete with equatorial mount, rigid full-length aluminum tripod, and accessories for only $795! Or a Meade 4" f/9 Achromatic Refractor, complete, for only $595!

Never before have Meade telescopes at these levels of optical and mechanical specifications been available at such low prices. And yet, both instruments are ready for a lifetime of exciting photo-visual applications.

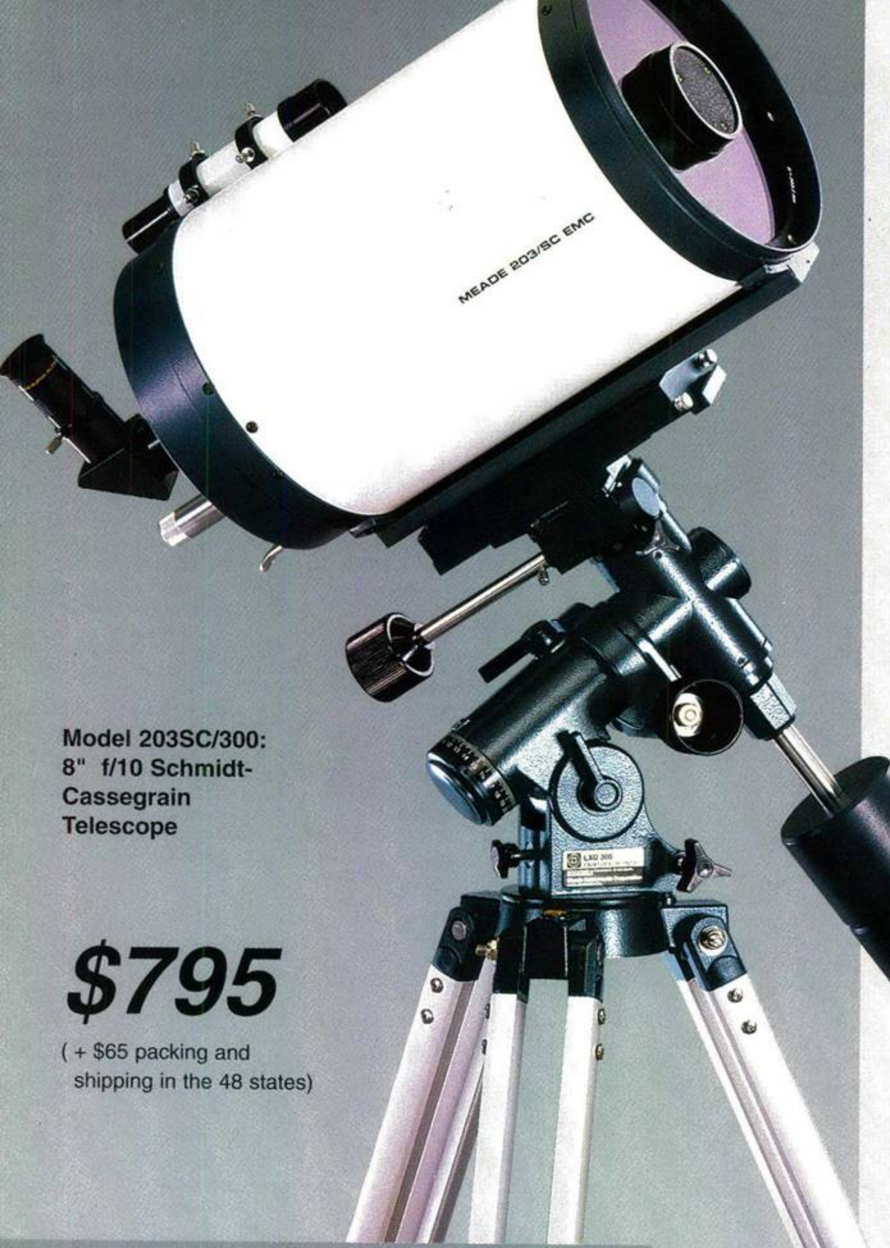
- **Optical Systems:** The Meade 203SC/300 includes the exact same optical tube assembly as more expensive Meade 8" Schmidt-Cassegrains, a diffraction-limited optical system that is, by far, the largest-selling in the world in its aperture class. Model 102ACHR/300 includes the exquisite Meade 4" air-spaced achromatic lens, corrected for spherical and chromatic aberrations. All 4" and 8" optics are EMC super multi-coated for maximum light transmission.

- **LXD 300 Equatorial Mount:** The high-performance Meade LXD 300 equatorial mount, with dual-axis aluminum worm gears, micrometric slow-motion controls, setting circles, and fine-adjust azimuth and elevation controls, provides an exceptionally strong, steady platform for Meade 4" and 8" models.

- **Observing Applications:** Meade 300-Series models permit an extremely wide array of photographic and visual observing opportunities, including astrophotography of the Moon and planets and even limited deep-space photography.

SPECIFICATIONS: Models 203SC/300 and 102ACHR/300 — Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 300 equatorial mount with aluminum worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 50°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions.

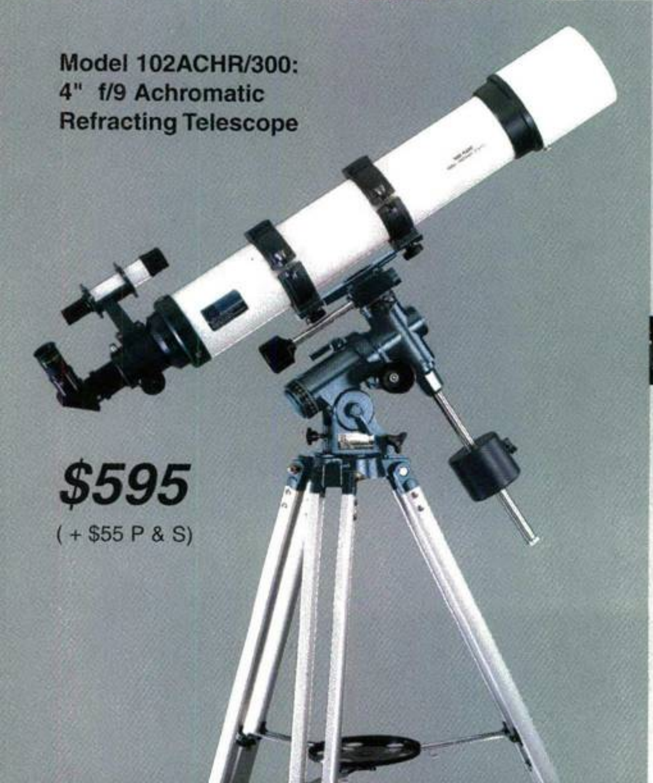
#535 R.A. Motor Drive System	**$99**
#812 Polar Alignment Finder	**49**



Model 203SC/300: 8" f/10 Schmidt-Cassegrain Telescope

$795

(+ $65 packing and shipping in the 48 states)



Model 102ACHR/300: 4" f/9 Achromatic Refracting Telescope

$595

(+ $55 P & S)

Prices listed are suggested U.S. national mail-order retail prices.

ADE

LXD 500

For even broader capability, use the Meade® high-precision LXD 500 equatorial mounting, with dual-axis bronze worm gears — the finest equatorial mounting available in its price class.

Manufactured to exclusive Meade standards of precision, the Meade LXD 500 equatorial mount is 20% larger than the LXD 300 mount and permits applications of the telescope, in conjunction with the optional 4-speed #1702 Dual-Axis Drive System, that include long-exposure deep-space astrophotography. Engraved setting circles on both axes allow for the location of faint objects directly from their catalogued coordinates.

Incorporating the same optical tube assemblies as the 300-Series, Meade 500-Series models offer a level of mechanical precision generally available only on telescopes costing hundreds of dollars more.

SPECIFICATIONS: Models 203SC/500 and 102ACHR/500— Each telescope includes 8" f/10 Schmidt-Cassegrain *or* 4" f/9 Achromatic Refractor optical tube assembly with EMC super multi-coatings; LXD 500 equatorial mount with oversize bearings, high-precision bronze worm gears, micrometric manual slow-motion controls, and setting circles on both axes; manual control for azimuth alignment; elevation control and scale for polar alignment at latitudes from 15° to 60°; adjustable full-length aluminum tripod with bubble level and accessory shelf; 6 x 30mm achromatic viewfinder; eyepiece-holder (1.25"); #918A diagonal prism (1.25"); Series 4000 Super Plössl 26mm eyepiece (203SC) *or* Series 3000 Plössl 25mm eyepiece (102ACHR); provision for addition of optional #812 Polar Alignment Finder; operating instructions.

#1701 R.A. Motor Drive System, with 4-speed controller	**$145**
#1702 Dual-Axis Drive System, with 4-speed controller	**195**
#812 Polar Alignment Finder	**49**

For details on the full range of Meade astronomical telescopes, CCD imagers, and accessories, call, write, or fax for your free copy of the Meade 100-page General Catalog.

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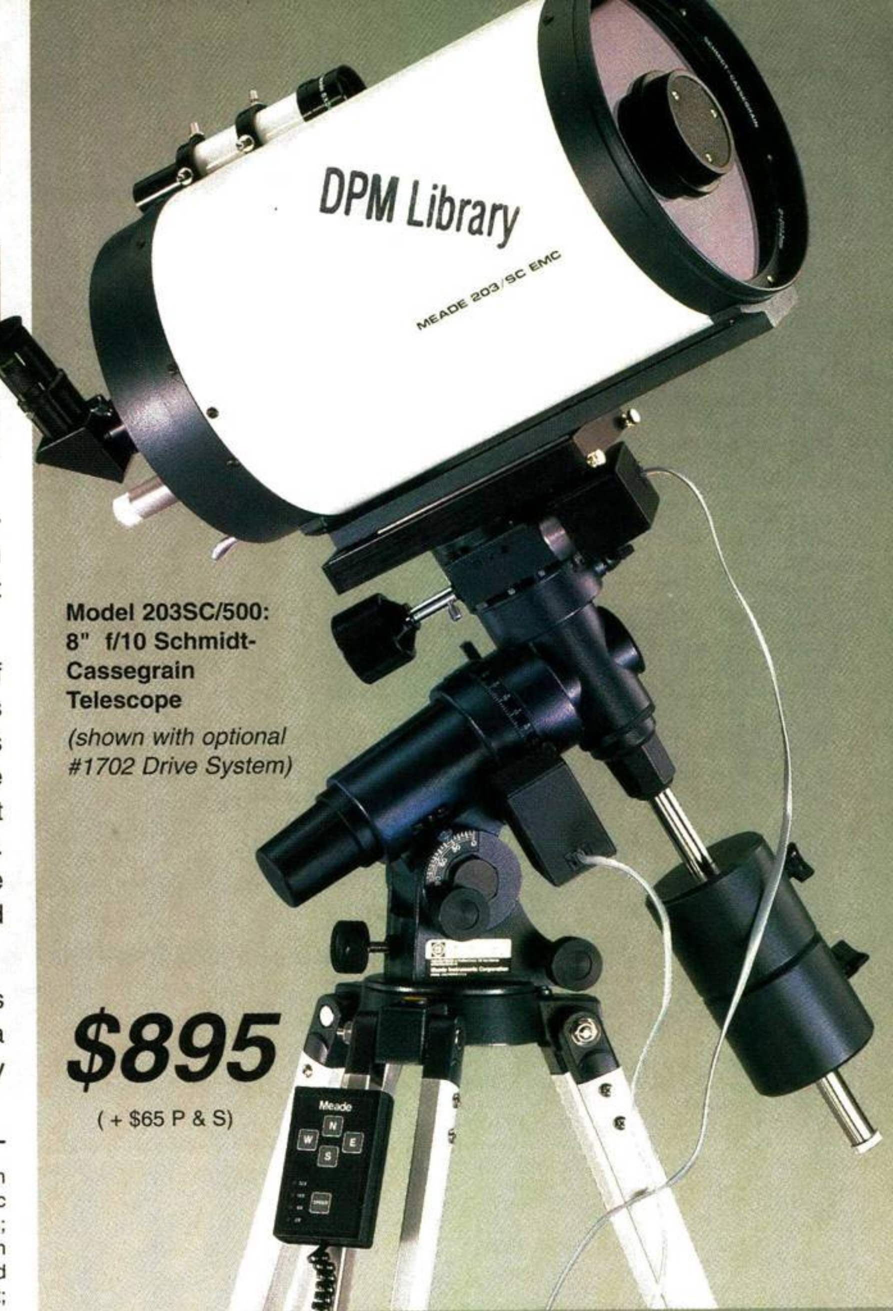

DPM Library

Model 203SC/500: 8" f/10 Schmidt-Cassegrain Telescope

(shown with optional #1702 Drive System)

$895

(+ $65 P & S)

Model 102ACHR/500: 4" f/9 Achromatic Refracting Telescope

$695

(+ $55 P & S)

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Astronomy®

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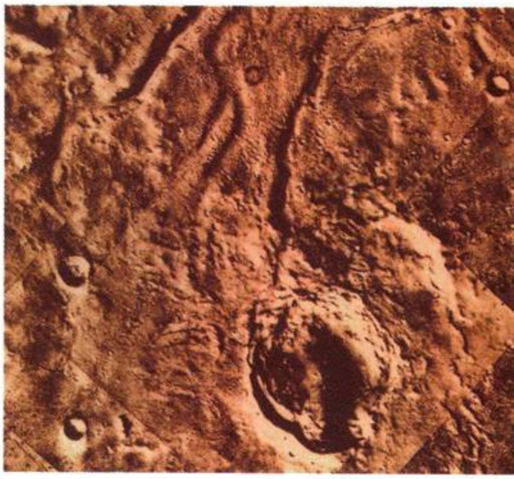
From *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.



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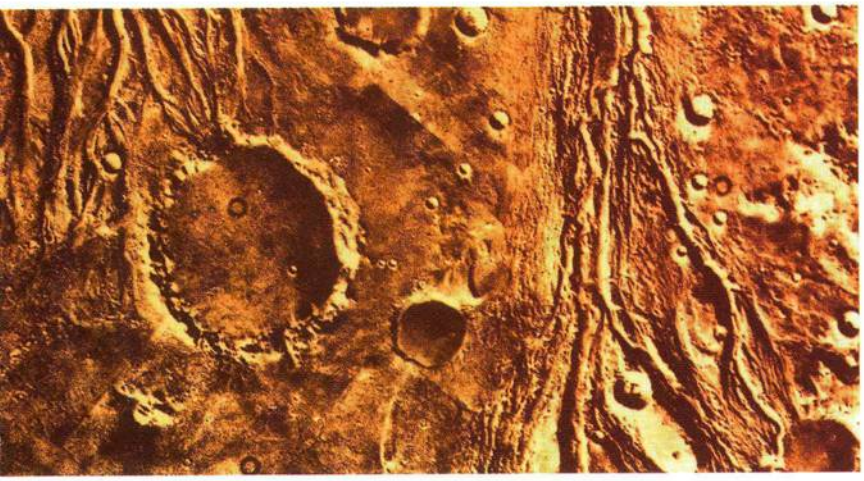

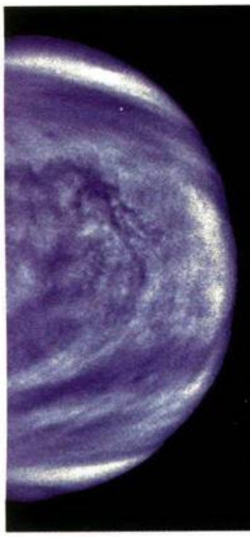

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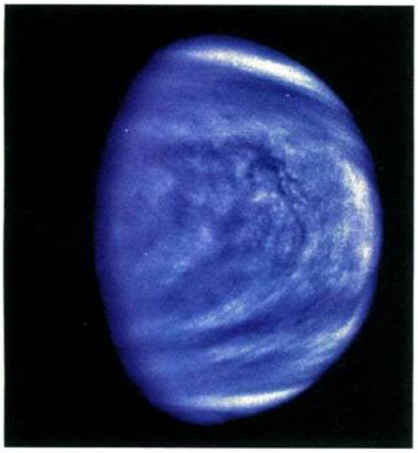
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Weighty Matters

My New York friend Steve Mirsky writes: Astronomy is a distinctly human activity — birds may navigate by the stars, but they probably don't spend much time contemplating them. I remember seeing human nature on full display in an astronomical setting in a visit to the Hayden Planetarium in New York City. At that time a popular exhibit at the Hayden (which is now being remodeled) was a group of scales that told visitors how much they would weigh elsewhere in the solar system. Most people, images of a near-weightless Neil Armstrong bounding in their minds, headed for the moon scale to shed about ⅚ of their weight. A few fearless souls, however, opted for the scale that shows what they would weigh if they could stand on the surface of the sun. A 150-pound visitor would tip the sun scale (which multiples Earth weight 28 times) at more than two tons. One brave woman was about to set foot on the sun scale when she suddenly realized the horror that awaited. So she turned to her husband and did what any veteran dieter would do — she handed him her pocketbook.


NASA/JPL/Galileo

What would you weigh on Venus?

If you have an interest in seeing what you weigh on other planets, we can help. You can get what you need to calculate your weight on Venus, Saturn, and Jupiter in our current Kids' Corner, page 80.

In other weighty matters, a story in AstroNews brings home how important weight is in the search for planets outside our solar system. To our view, some stars will wobble because they are being tugged about by an unseen companion. But knowing for sure if the companion is a planet depends on figuring out its mass. Researchers recently have proven that a planet must be causing the wobble in 55 Cancri. In that star system, detected about three years ago, the orbiting partner is too light to be either a dim star or brown dwarf, the only other currently known possibilities (see page 24).

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Meade Instruments Corporation

ETX Astro Telescope mounted on optional Field Tripod.

Diffraction-limited imaging and ultraportability ...at only $595, complete!

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Tilt and lock the ETX Field Tripod to 90° for terrestrial observing.

SPECIFICATIONS: ETX Astro Telescope — Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. Net weight 9 lbs.

$595 (+ $20 packing & shipping in the 48 states)

ETX Field Tripod — The rigid, full-length ETX Field Tripod allows for seated or standing observations through the telescope; tripod height is adjustable from 34" to 54". Micrometric controls in both azimuth and elevation-angle permit precise polar alignment of the telescope's fork mount for astronomical applications. For terrestrial observing, where altazimuth orientation is desirable, the tripod head tilts to 90°. The telescope attaches to the tripod in seconds with two thumbscrews. Net weight 11 lbs.

$169 (+ $10 packing & shipping in the 48 states)

Prices shown are suggested U.S. mail-order retail prices.

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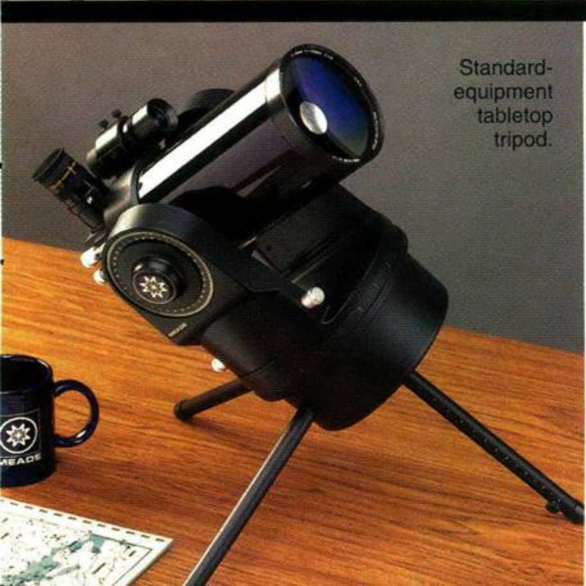
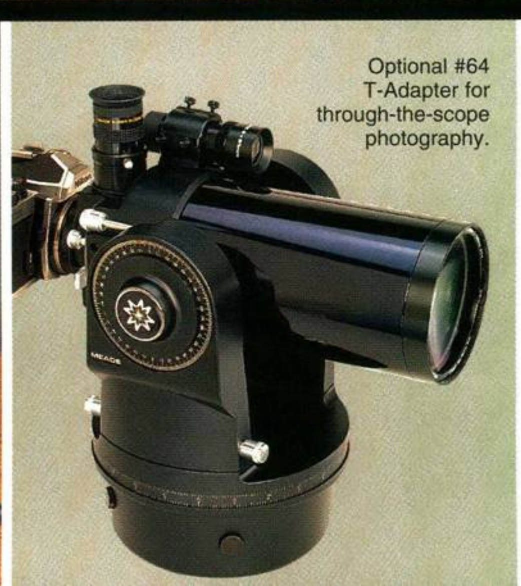


Standard-equipment tabletop tripod.



Optional #64 T-Adapter for through-the-scope photography.

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MEADE LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

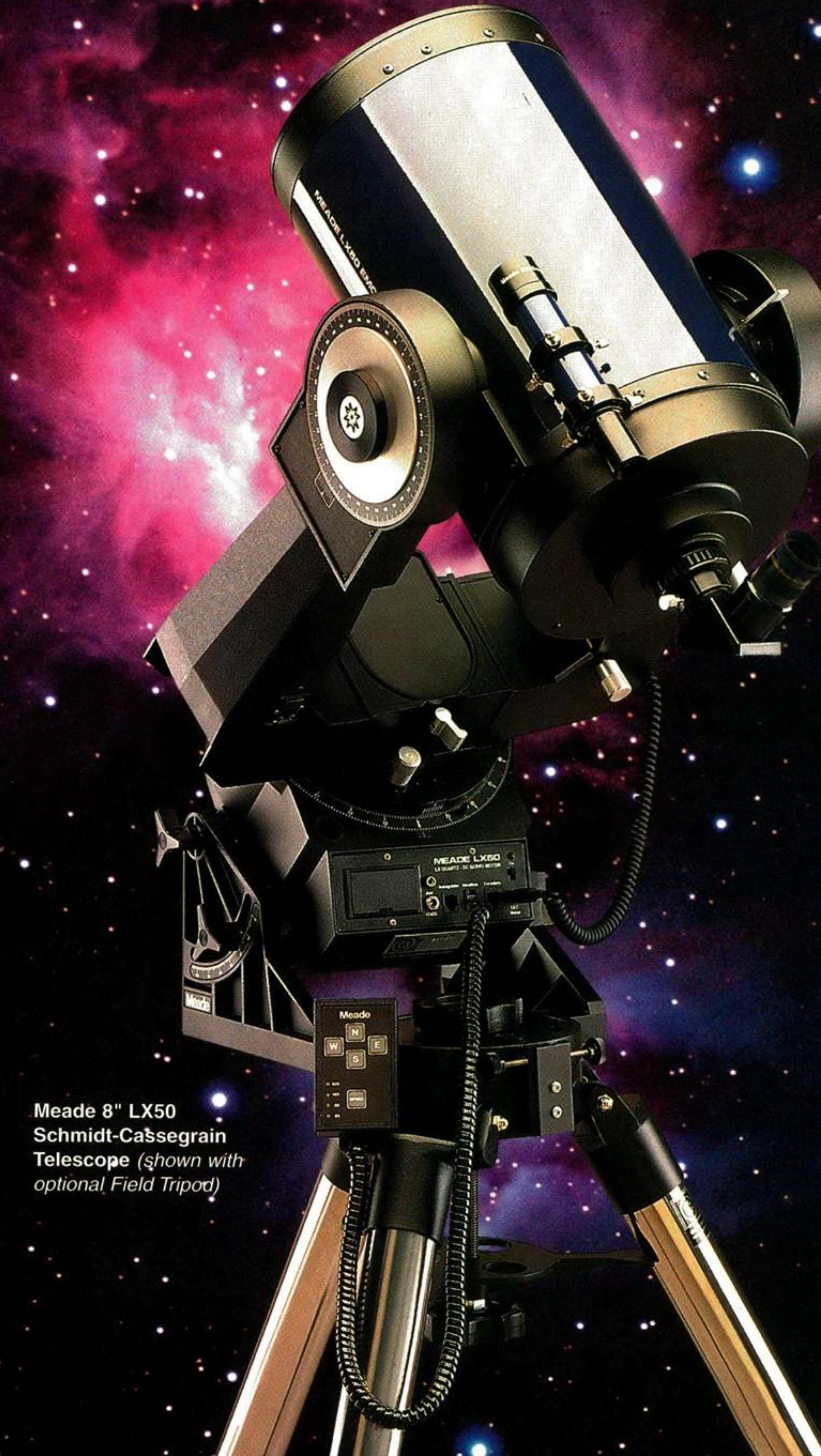
SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

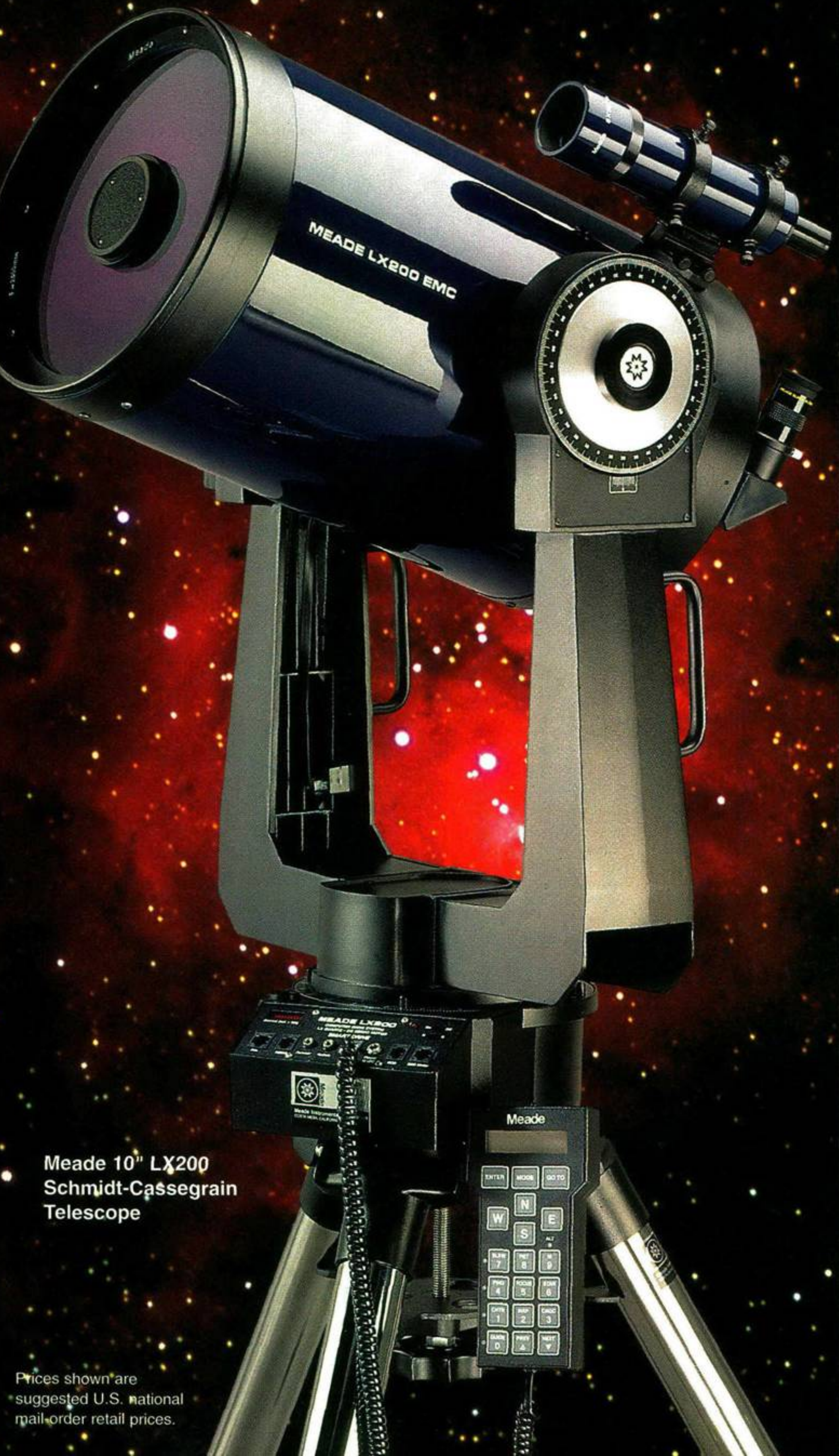
Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200



Meade 10" LX200
Schmidt-Cassegrain
Telescope

Prices shown are suggested U.S. national mail-order retail prices.

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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MEADE STARFINDER DOBSONIANS

Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **2 - Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
ENTER
MODE
PREV
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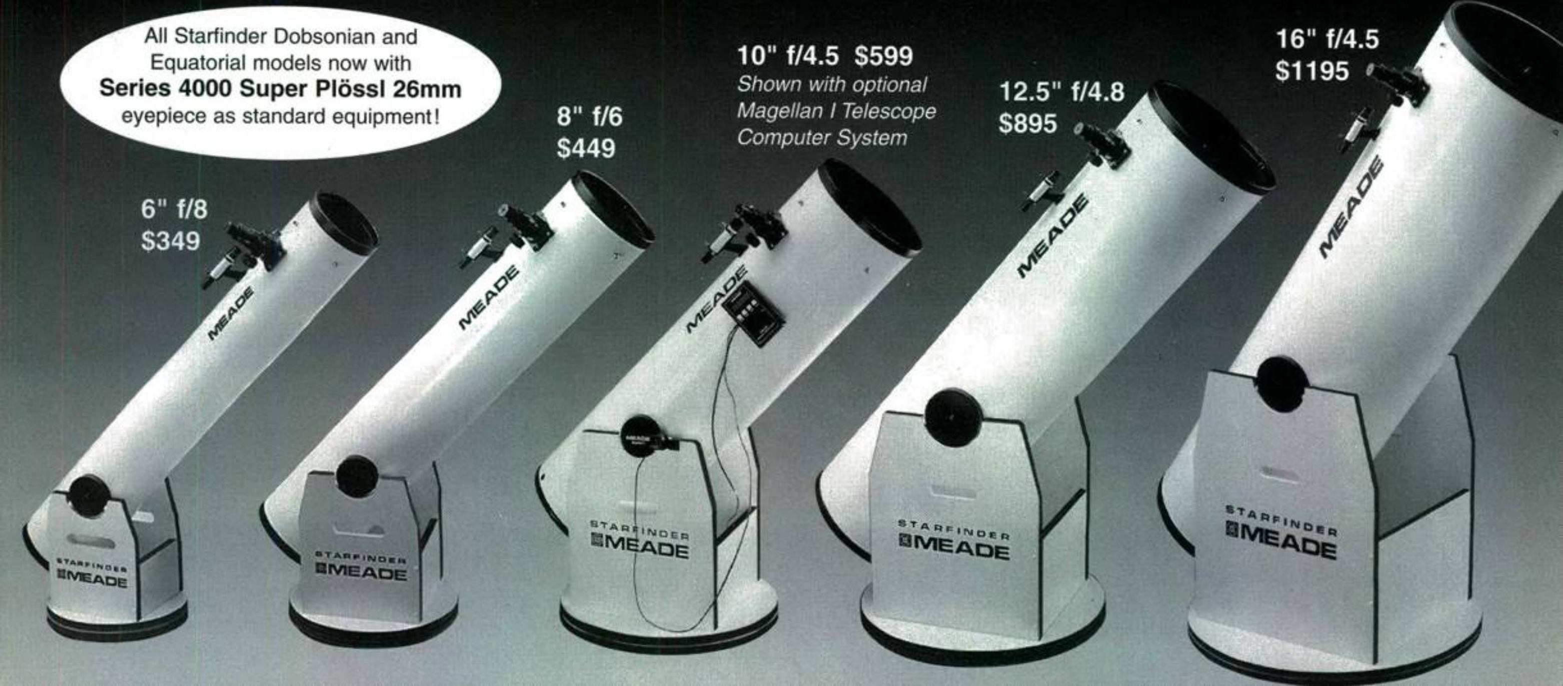
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



All Starfinder Dobsonian and Equatorial models now with **Series 4000 Super Plössl 26mm** eyepiece as standard equipment!

6" f/8 $349

8" f/6 $449

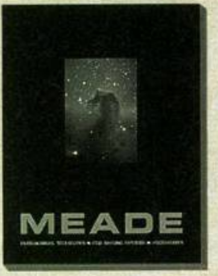
10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12.5" f/4.8 $895

16" f/4.5 $1195

MEADE
STARFINDER EQUATORIALS

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*



The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 100-page Meade General Catalog.

Write, call, or fax Meade Instruments for your free copy!

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

MEADE
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MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER - CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

To Order: Contact your authorized Meade Advanced Products Mail-Order Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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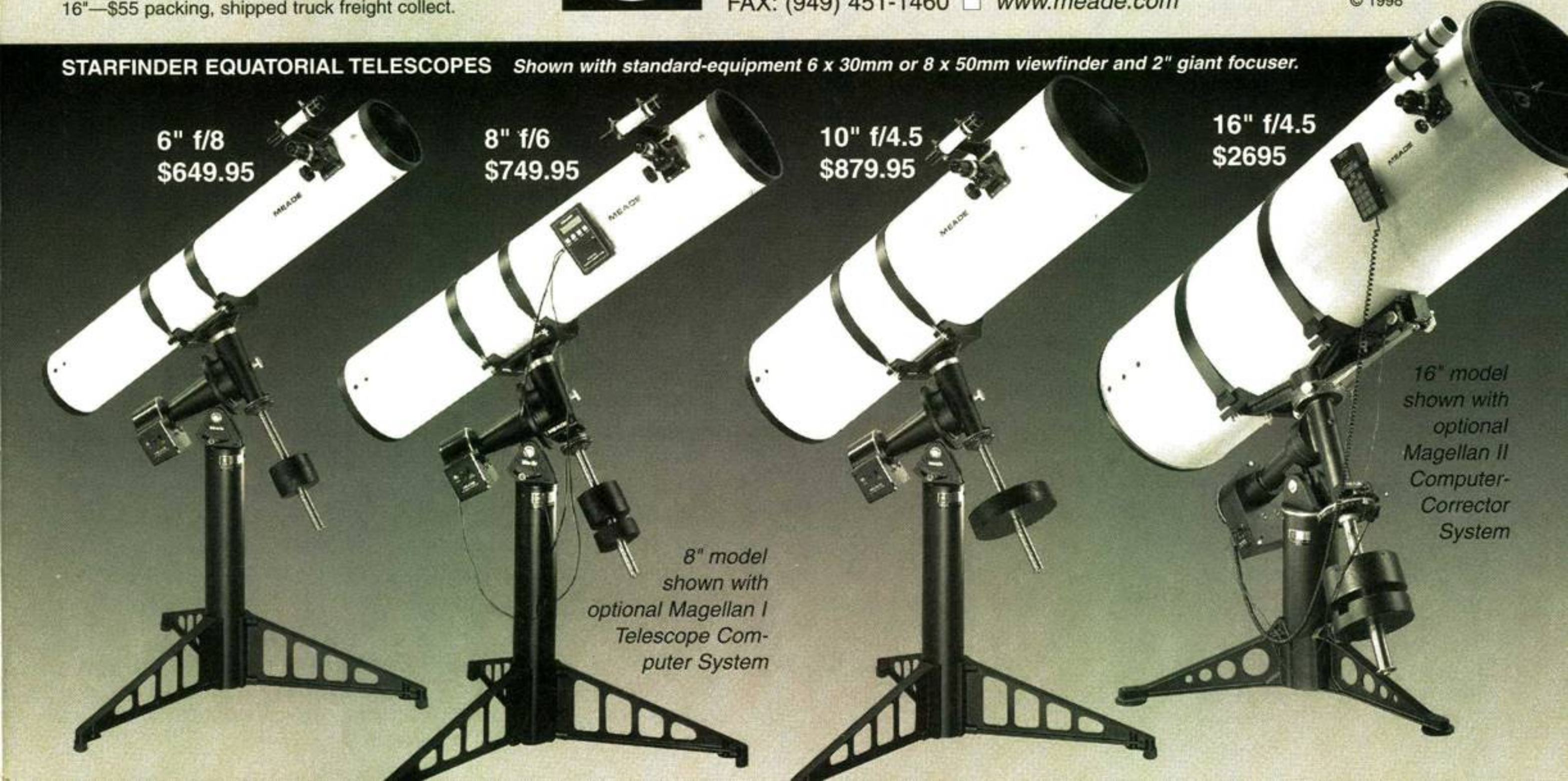
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



6" f/8
$649.95

8" f/6
$749.95

10" f/4.5
$879.95

16" f/4.5
$2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

8" LX10

8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

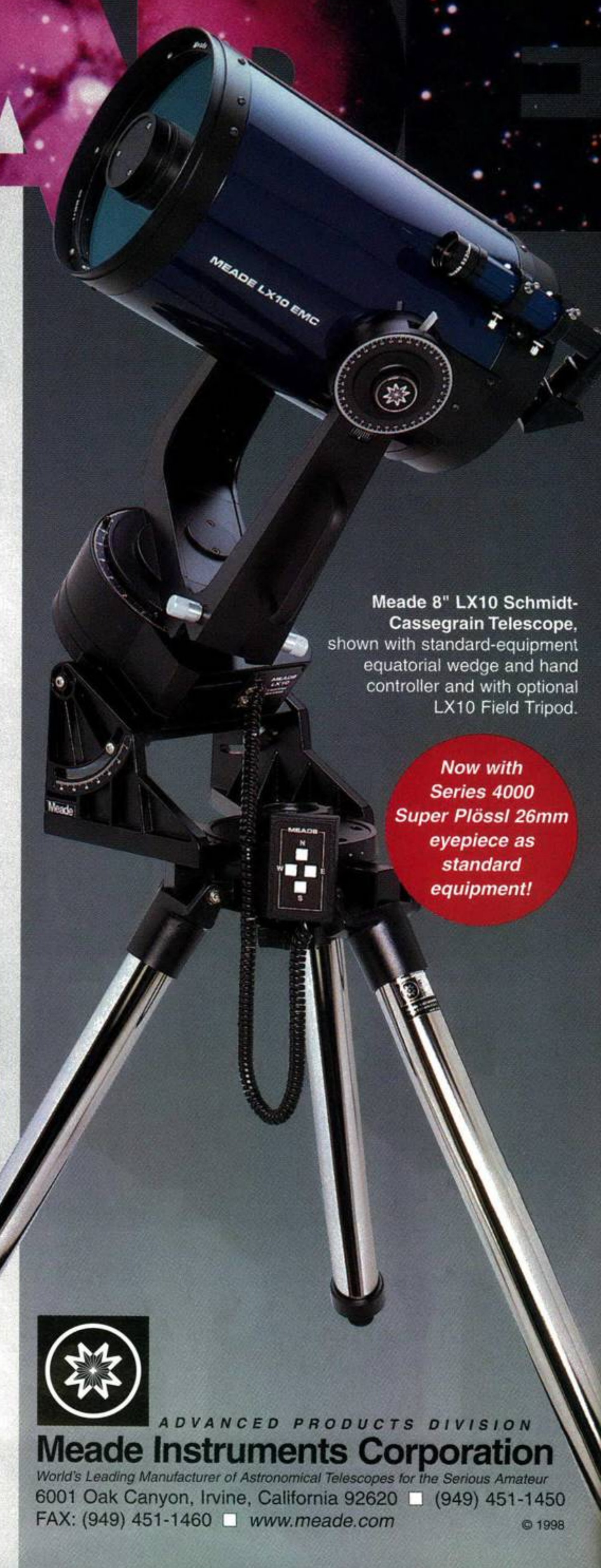
8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	195.
Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 *Deluxe*, with 12,218-object database	375.

The 100-page Meade General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers.
Prices shown are suggested U.S. mail-order prices.



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

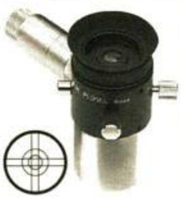
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



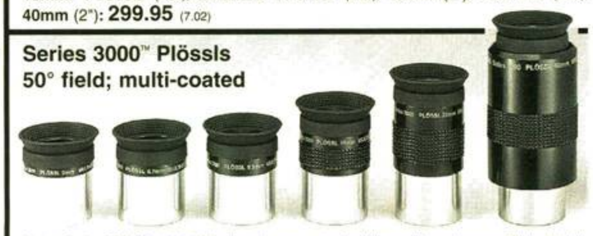
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated



Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
New!
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 717-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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Light-Pollution Protest

Arkansas Tech University, where I am enrolled as a student, has lit up the exteriors of its new student apartments as if they were gambling casinos. Much of the lighting is gaudy, wasteful and should be eliminated.

Of course, everyone on campus deserves safe, illuminated walkways. This university or any public entity can accomplish this and save money at the same time by directing lights downward, effectively providing more light where it is needed — on the ground. Allowing light to escape upward only creates a murky glow in the night sky. While many people are familiar with air and water pollution, few realize we are also losing another Arkansas natural resource — the dark star-lit sky. The United States wastes about $1.5 billion per year due to light pollution, according to a study by the nonprofit International Dark-Sky Association.

In 1997, a state group gave high marks to the university's astronomy program. Installing lights with so-called full-cutoff shielding is the most sensible step toward preserving the program by brightening the walkways and darkening the skies. — *Robert Tout Campbell, Russellville, Arkansas*

Nelson Falsarella

You think you go through phases. The moon's repeat every 29.5 days, and for most of each month Earth's companion is the most conspicuous celestial object in the night sky.

Moonstruck

I have appreciated your ongoing series "Lunar Musings" because other astronomy magazines seem to look beyond the moon to bigger and better things. However, the moon is full of wonderful treasures, even for amateurs with small-to-moderate-sized scopes. I also appreciated the star party *Astronomy* sponsored last summer in Albuquerque, New Mexico. — *Travis Hodges, Los Lunas, New Mexico*

Will Clinton, Congress Listen?

My petition urging President Clinton to renew government funding for NASA's SETI program, the Search for Extraterrestrial Intelligence, was mailed to the White House in January. The petition, along with the signatures of 25 distinguished representatives of science, was published in the December issue of *Astronomy*. The petition was the result of at least two years of organizational work with the assistance and advice friends such as Brian Aldiss, Greg Bear, Arthur C. Clarke, Timothy Ferris, Jack McDevitt and Dennis Overbye. Several signatures have been added since December, include those of James Trefil, David Brin, Ben Bova, and myself.

We are asking President Clinton to continue an important scientific heritage by paying scientists to conduct continuous SETI surveys from 1999 to at least 2010. Congress and Clinton should work together to repair the mistake of the cancellation of SETI funding in 1993. Renewed funding will allow SETI to pursue the discovery of the most fundamental event imaginable in humankind's history: contact with an extraterrestrial civilization.

I would appreciate the support of *Astronomy* readers for the United States' funding of SETI. They can write to President Clinton at the White House (1600 Pennsylvania Ave., Washington, DC 20500), urging permanent funding of this vital project. — *Tobias Daniel Wabbel (TDWabbel@compuserve.com), Germany*

A Lunar High Down Under

On October 4, I climbed Mt. Gravatt in metropolitan Brisbane in the sunshine state of Queensland, Australia. Although suffering a little from the city's light pollution and smog, the mountain, under a clear sky, was a good place to watch the moon's occultation of Jupiter.

At sunset, the darkened limb of the moon approached the bright planet. Jupiter faded gently and disappeared as

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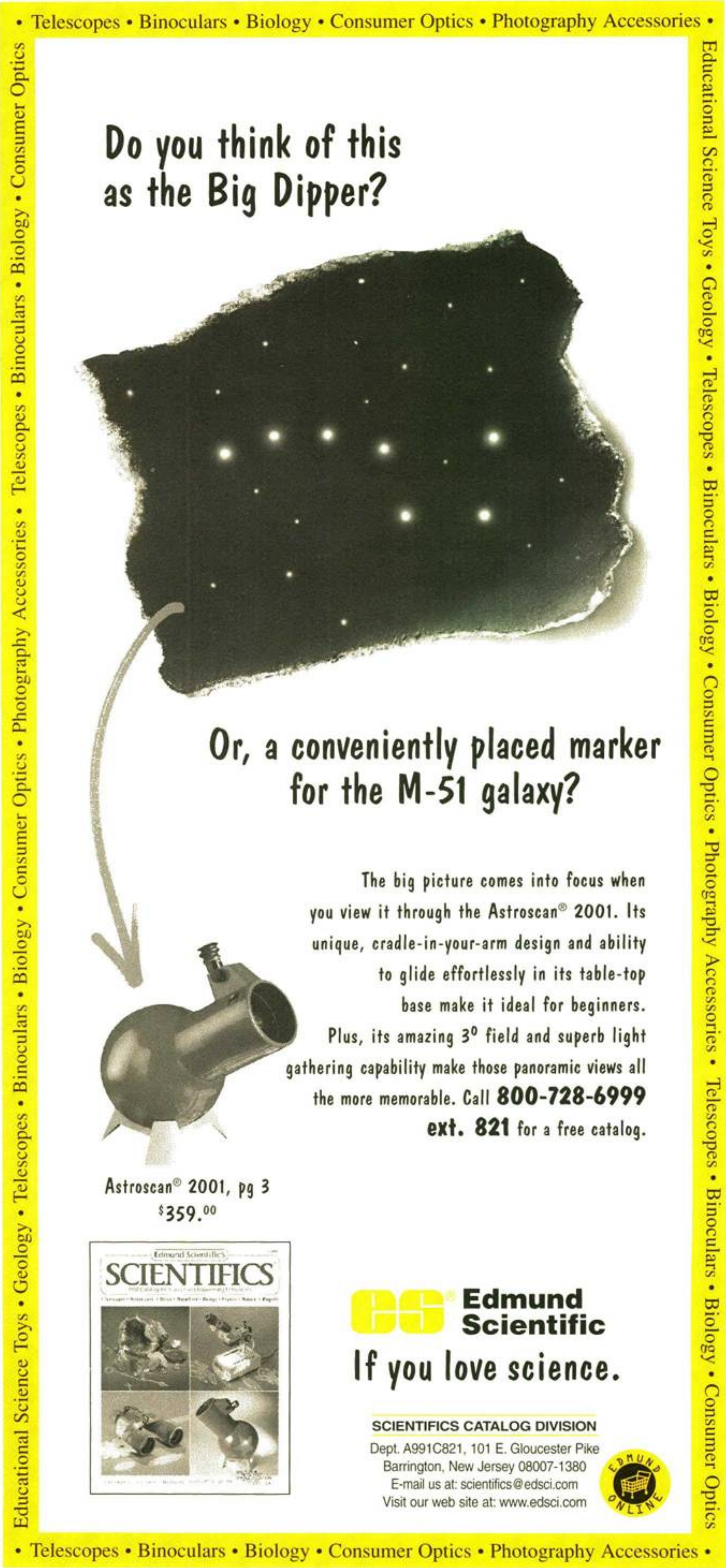

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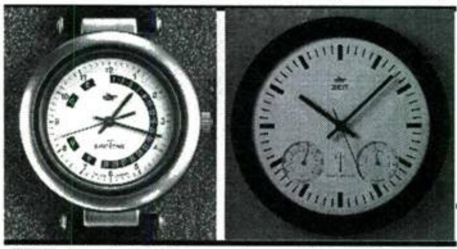

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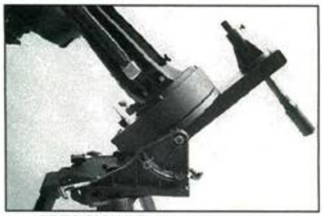
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I watched with my Russian binoculars. When the giant planet first re-emerged roughly one hour later, it looked like a bump on the almost-full moon, which by then appeared fully bright. The planet gradually separated and returned to full view. The sight was a spectacular one.

The next evening was the Chinese mid-autumn or lantern-festival moon. Watching the moon was never so rewarding and worth the mosquito bites. — *Robert McLean, Taringa, Queensland, Australia*

Musings about Hawking

The story about Stephen Hawking in the December issue stated that he "had annoyed some critics, because he had written that a theory in physics is just a mathematical model and that it makes no sense to ask whether it corresponds to reality." I don't know what Hawking thinks of God. However, he is far beyond the "Learn'd Theologians" mentioned in a story in the December issue about religion and science.

Hawking seems to understand that what a person makes in his or her mind and thinks is reality is far short of the reality God has made. — *Robert Supino, Allyn, Washington*

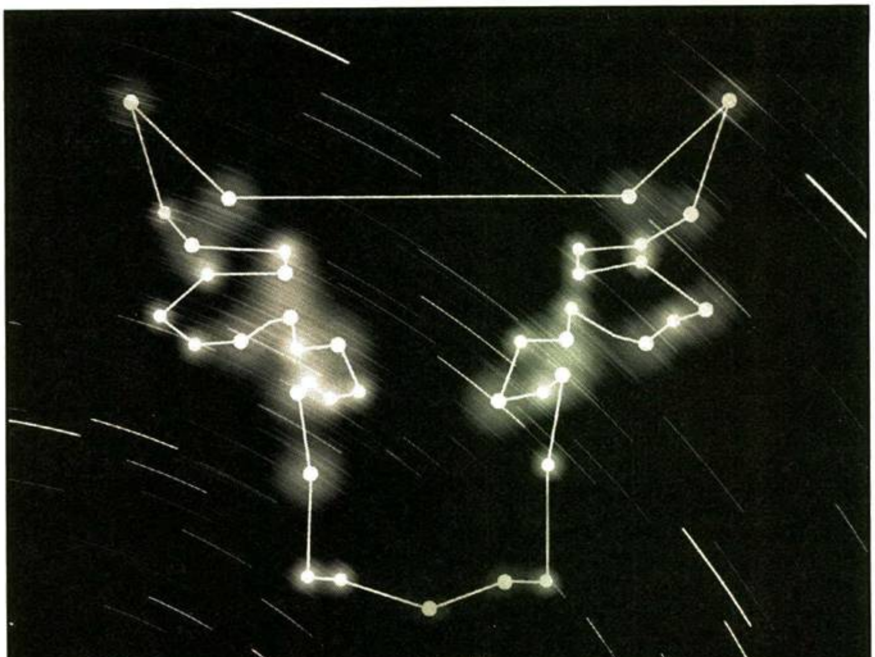
Memories of Mentoring

I taught elementary-school students in Washington, D.C., from 1994 through 1996, which is why I've been relishing your stories that emphasize the importance of educating young astronomers. I didn't dump numbers on them and made sure they had something to actually do.

My students made papier-mâché planets and comets, and they learned to locate stars and planets with software.

Most continue to have an interest in astronomy, several have completed astronomy-related science-fair projects, and one is continuing her astronomy education as a hobby. — *Jerry Elya, Fairfield, Ohio*

Astronomy invites you to talk back. Send letters to Astronomy *Talking Back, P.O. Box 1612, Waukesha, WI 53187; e-mail to talking@astronomy.com. Letters may be edited for space and clarity. If you want to talk back to us, please visit our website, http://www.astronomy.com.*



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Astronomy Magazine

StarFest '99

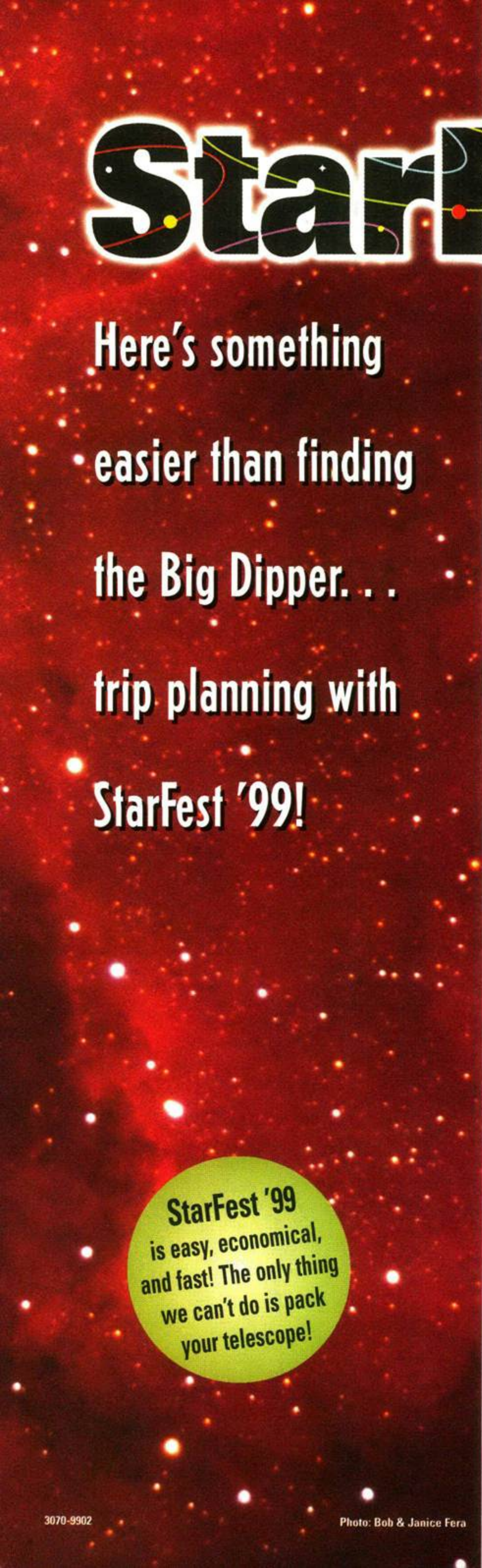

Photo: Bob & Janice Fera

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Astronomical Society of the Pacific • July 1–7
(Includes Universe '99 - July 2–4) Toronto, Ontario, Canada
Register with Lori Keechler at (415) 337-1100 or e-mail lkeechler@aspsky.org
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Nebraska Star Party • July 18–25
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Oregon Star Party • August 20–23
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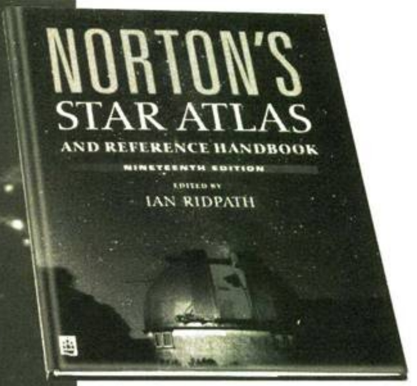

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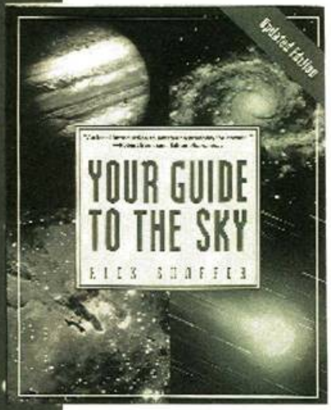

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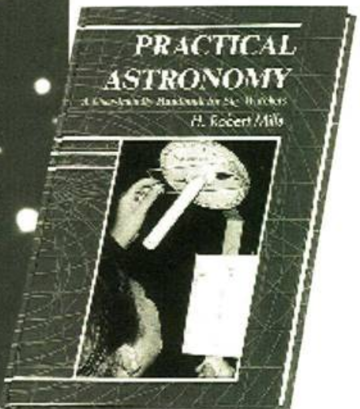

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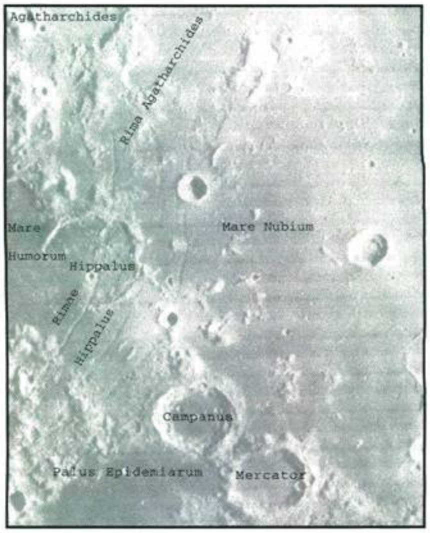
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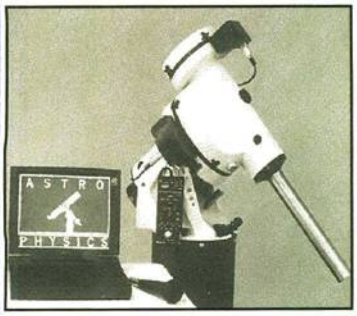

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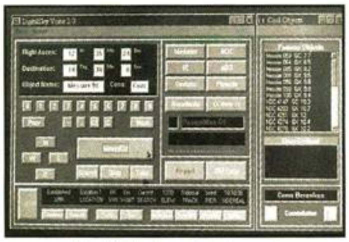

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Star diagonal and eyepiece sold separately.

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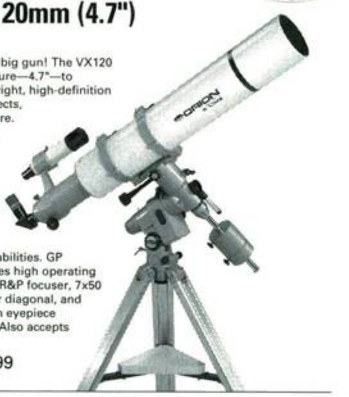

We're breaking out the big gun! The VX120 has enough clear aperture—4.7"—to deliver exceptionally bright, high-definition views of deep-sky subjects, not just solar system fare. Its 4-element, 2-group objective achromat provides added color correction and field flattening. Relatively fast f-ratio of 6.7 (focal length 800mm) gives it awesome astrophotographic capabilities. GP equatorial mount insures high operating precision and stability. R&P focuser, 7x50 finder scope, prism star diagonal, and 20mm (40x) Lanthanum eyepiece (1.25") come standard. Also accepts 2" visual back.

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6" (f/8)	$359
8" (f/6)	$469
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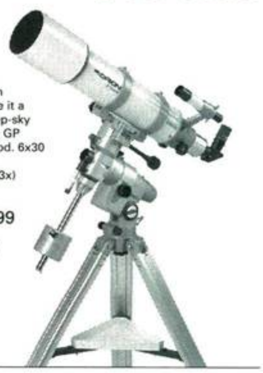
ORION

VX102-ED GP Refractor

ORION



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CIRCUMSTELLAR DISKS

The Planet-Disk Connection

▶ Astronomers have recently imaged a disk of cold dust around the star Rho^1 Cancri (also known as 55 Cancri), a star 40 light-years away that's slightly smaller and cooler than the sun. Even though astronomers have previously imaged similar disks surrounding about half a dozen mature stars, the Rho^1 Cancri disk is the first to be imaged around a star that is known to be orbited by a planet.

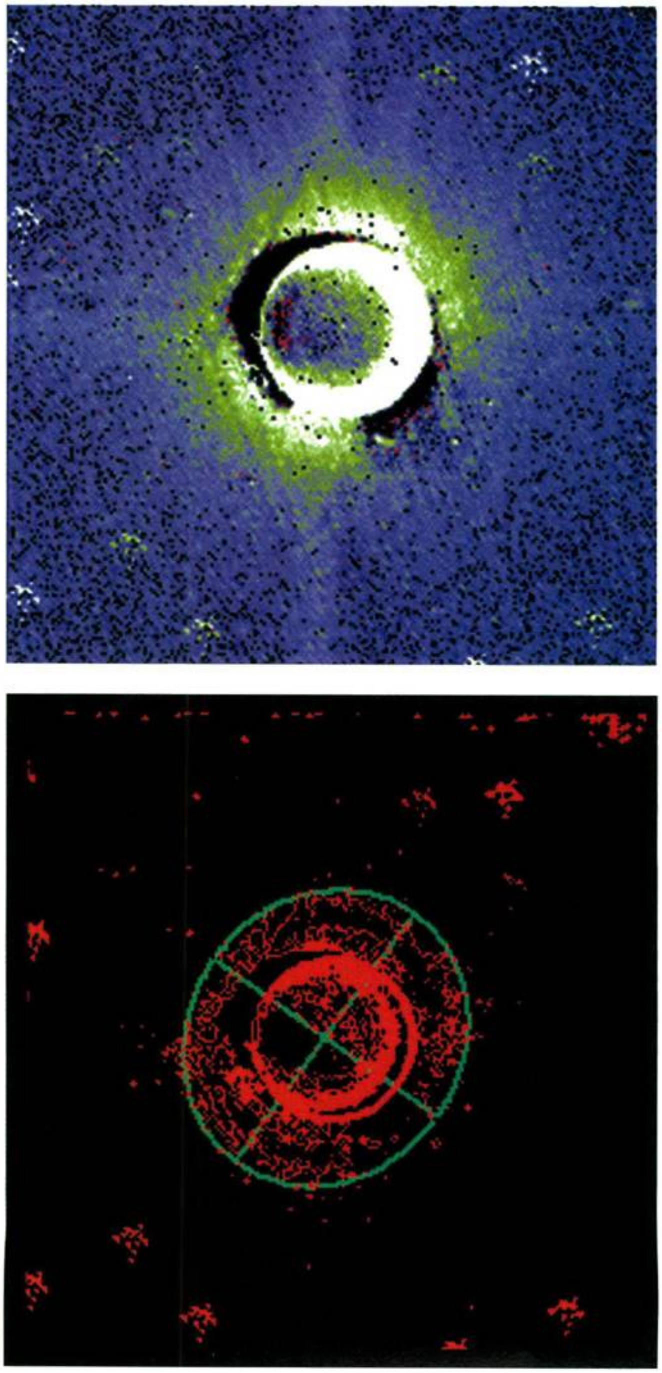
University of Arizona astronomers David Trilling and Robert Brown imaged the faint disk with NASA's Infrared Telescope Facility on Mauna Kea; a coronagraph built by Brown was used to block out the star's light. The image shows the disk extending from about 27 to 44 astronomical units (one astronomical unit is the average distance between the sun and Earth) from the star. It appears to be similar in both size and chemical composition to our solar system's Kuiper Belt — a swarm of small, icy bodies beyond Neptune.

"If you were on Rho^1 Cancri looking at our solar system, it wouldn't look all that different. The disk seems to be saying that the Rho^1 Cancri system has a very similar history to our solar system," says Trilling, who published the team's paper in the October 22, 1998, *Nature.*

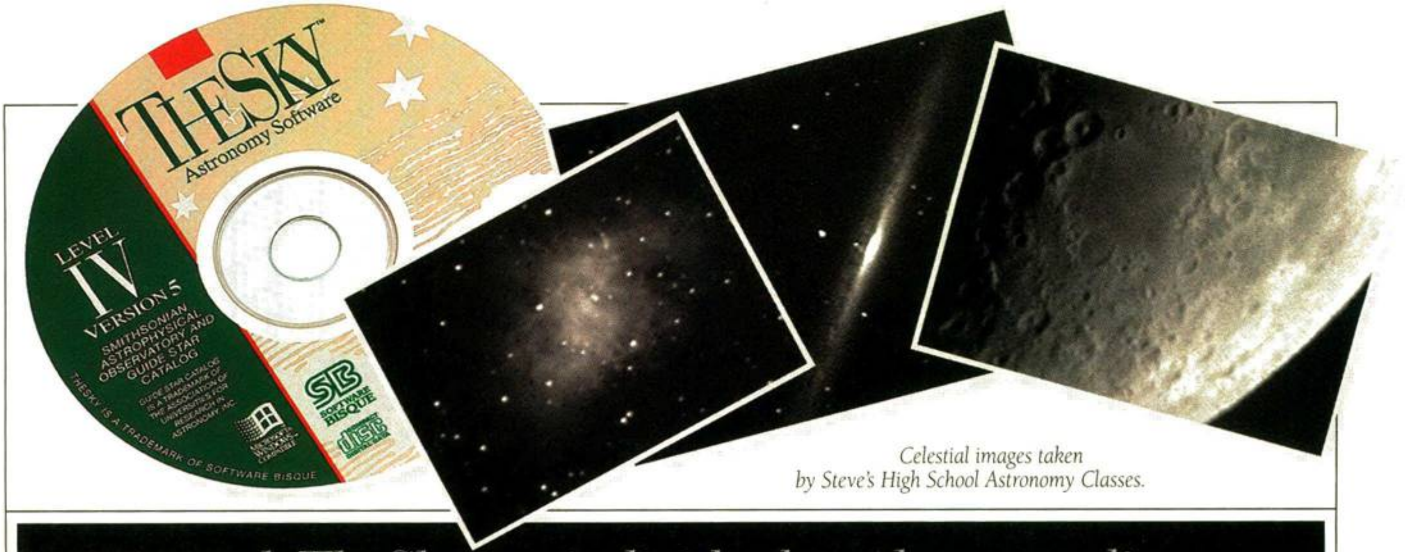
Geoff Marcy and Paul Butler discovered Rho^1 Cancri's planet in 1996 by detecting the wobble that its gravity induces on the parent star. But their method doesn't reveal how much a planet's orbit is tilted with respect to our line of sight. Without that information, Marcy and Butler could only calculate the planet's minimum mass: 85 percent that of Jupiter. The small but nagging possibility remained that the companion was much heavier, perhaps heavy enough to be a brown dwarf or low-mass star.

Trilling and Brown's image virtually erases this concern. The disk is almost certainly circular, but it appears elliptical because it's tilted about 63° to our line of sight. If the planet orbits Rho^1 Cancri in the same plane as the disk, its mass is 1.9 Jupiters, give or take about half a Jupiter. "In our solar system, just about everything lies in the same plane, and there's no reason to think the Rho^1 Cancri system is particularly unusual compared to our solar system," says Trilling. If this assumption is indeed correct, and most astronomers think that it is, a 1.9-Jupiter-mass companion is far too light to be a brown dwarf or star.

Rho^1 Cancri's disk may soon have company. The star was just the first on Trilling and Brown's observing list. Although the results from later observing runs haven't been published yet, "There are a number of disks sitting in our pocket," says Brown.
— **Robert Naeye**



In an infrared image (top), a disk of cold dust around the star Rho^1 Cancri appears yellow; the central star has been blotted out by a coronagraph. The disk appears similar to our solar system's Kuiper Belt. A contour plot of the disk (bottom) suggests that it is a circular disk that is tipped 63° to our line of sight. David Trilling and Robert Brown (University of Arizona)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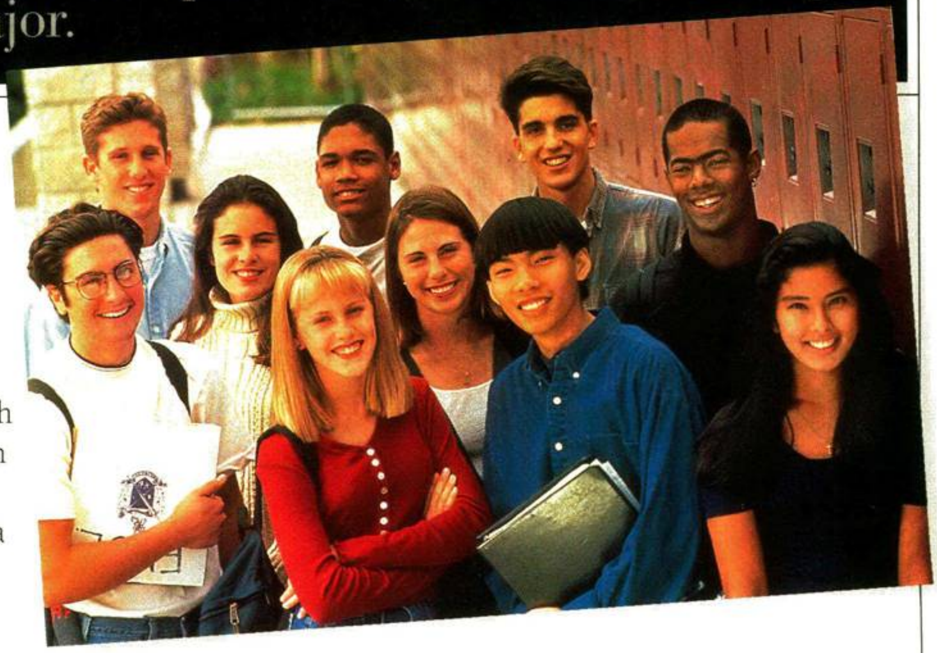

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GALILEO

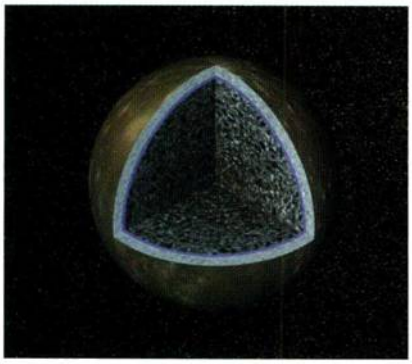
Callisto's Surprising Ocean

"Water, water, everywhere, Nor any drop to drink."

With apologies to Samuel Taylor Coleridge, the English poet couldn't have had any idea that his "The Rime of the Ancient Mariner" would prove prophetic in describing the moons of Jupiter. While evidence continues to mount that Europa's icy surface covers an ocean of liquid water, a new study provides unexpected and tantalizing clues that its bigger sibling Callisto may also harbor a subsurface ocean.

"Until now, we thought Callisto was a dead and boring moon, just a hunk of rock and ice," says Margaret

(see "Callisto," p. 28)



Callisto's heavily cratered surface (below) masks a startling secret: An ocean of liquid water (shown as a thin blue layer in the illustration to the right) apparently lurks beneath the icy crust.

NASA/JPL

ASTRONOMY EDUCATION

Learning to Look for Life

Class of 1999 take note: The University of Washington is looking for a few good Men and Women in Black. The school announced in September that with funding from the National Science Foundation, it will launch a first-of-its-kind graduate program in astrobiology, intended to train doctoral students to search for and study life in the universe.

Earning college credit while scouting for extraterrestrial life sounds like the ultimate alien hunter's dream, but students should not rush to pack the Tang and space rations just yet. This program's first mission will be to planet Earth.

Researchers in disciplines ranging from astronomy and atmospheric science to oceanography and microbiology will cooperate to discover just what it might take for life to arise on other planets and their moons, by learning how life developed and survives under demanding conditions closer to home.

"We want to study life in extreme environments on Earth, such as high-temperature hydrothermal vents, freezing sea ice, and subterranean basalt formations," explains the program's director, microbiologist James Staley. "These systems serve as excellent models to study microbial life and may be similar to environments on other planetary bodies."

The hope is that recipes for life-giving geology, chemistry, and climate on Earth will eventually help pinpoint sites likely to harbor microbial life on celestial bodies such as Mars or Jupiter's icy moon, Europa. In the meantime, students can expect to learn a great deal about poorly-understood organisms on the planet they call home.

The University of Washington is not the only school with plans to give students a taste of the search for life in space. NASA's newly formed Astrobiology Institute will offer opportunities as well, as collaborations get underway between NASA scientists and professors at five participating universities. All of which adds up to fun for young explorers with their feet on the ground but their heads in the stars. — MIA SCHMIEDESKAMP

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Scientists involved in the search for extraterrestrial intelligence (SETI) developed SETI@home because they lack the computer power to process the enormous reams of data

(see "Discover ET," p. 28)

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(*Callisto*)

Kivelson of UCLA, the principal investigator for the Galileo spacecraft's magnetometer experiment.

Callisto is the second largest of the jovian satellites, and it's nearly the same size as Mercury. It also happens to be the most heavily cratered body in the solar system and bears no sign that its surface has been modified from below. Compare that with Europa, whose incredibly smooth surface seems scrubbed clean of nearly all impact craters, and ice floes appear to have drifted as if on water.

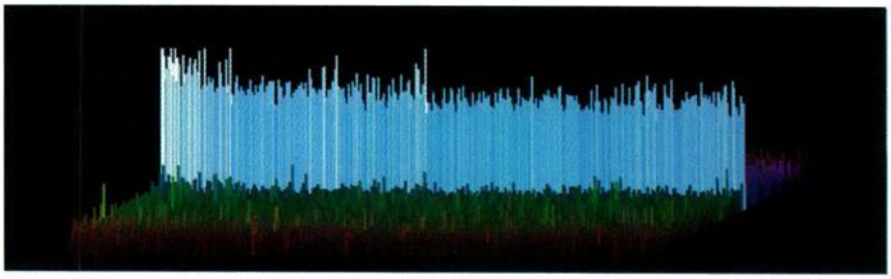
In the October 22, 1998, *Nature*, Kivelson and her colleagues report Galileo measurements of the magnetic fields in the vicinity of both Callisto and Europa. They found that as Jupiter's intense magnetic field rotates past the moons, it induces electrical currents in Callisto and Europa that in turn generate secondary magnetic fields.

But where can the electrical currents flow? There's not enough material in the moons' extremely tenuous atmospheres, and their icy surfaces conduct electricity poorly. The most straightforward explanation is that each moon possesses an ocean of salty water beneath its icy crust.

That comes as no surprise on Europa, where abundant heat from massive tides warms the interior, and the surface shows ample evidence of being altered by changes from below. But Callisto shows no tidal heating, no signs that the surface has been modified by anything internal to the moon, and even the rock and ice of the interior haven't totally separated into distinct layers.

The planetary scientists think Callisto's heat may be left over from the moon's formation 4.6 billion years ago or perhaps from the slow decay of radioactive elements in its interior. The salt in the water would act as a natural antifreeze.

The team also speculates that Ganymede, the largest of Jupiter's 16 known satellites, may also have a subsurface ocean. Unfortunately, Ganymede's own strong magnetic field would mask any secondary field like those found at Callisto and Europa. — Richard Talcott



As SETI@home runs on your computer, your screen might display something like this.

David Anderson (University of California at Berkeley)

(*Discover ET*)

collected by their radio telescopes. In order to catch an ET signal that might otherwise go unnoticed, they are soliciting the help of computer users worldwide.

Each computer will process small, 250-kilobyte chunks of data collected by a SETI program run by the University of California at Berkeley. This program gathers data at the 305-meter Arecibo radio telescope in Puerto Rico (seen in the movie *Contact*).

To participate, all you need to do is visit the website listed below and download SETI@home, which will take about an hour, depending on the speed of your modem. The 250-kilobyte chunks of Arecibo data take just a few minutes to download. SETI@home works like a screen saver; if your computer is idle for more than a few minutes, the program kicks in and processes data while you're not using it. After a few days, a message on your screen will tell you that the data has been processed. At that stage, all you have to do is connect to the Internet and the data will automatically upload to Berkeley — a process that will take less than a minute.

Dan Werthimer, one of the project's principal investigators, estimates your chances of finding ET at about one in 10 million. But if your computer does register a possible ET signal, and if the signal is subsequently confirmed by further observations, "You'd become quite famous," he says.

SETI@home, which is sponsored by the Planetary Society, Sun Microsystems, Fujifilm Computer Products, and Paramount Pictures, will be available in April. To join the 100,000 people who have already signed up, go to http://setiathome.ssl.berkeley.edu.

DETECTORS

Snatching Every Photon

In a technical discovery with far-reaching implications to astronomers, a team of scientists from Stanford University and the National Institute of Standards and Technology has patented a new type of light detector that can measure infrared, optical, and ultraviolet light with exceptional precision. Unlike conventional CCD detectors used by professional astronomers, this new device is so sensitive that it can measure the energy and time of arrival of single photons of light.

"This technology is immediately of interest to astrophysicists studying objects such as pulsars, where time and energy

(*see "Photons," p. 30*)

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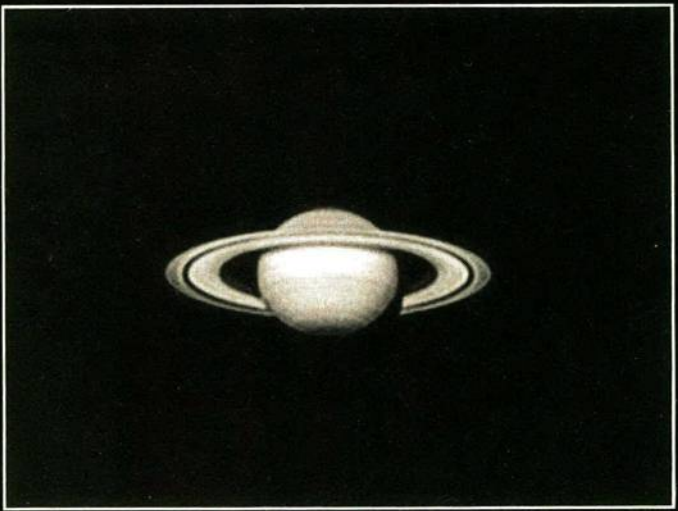

Saturn. *This remarkable ST-5C image was taken from the rooftop of the observer's apartment building using a 10" f/10 SCT and 2X barlow. The image clearly shows the Cassini division, Encke gap, inner crepe ring, brightening in the ring structure and atmospheric detail on the planet. Courtesy Antonio Jose Cidadao, Member of A.P.A.A (Associaiacao Portuguesa de Astronomos Amadores).*

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COMET HALE-BOPP

Rocket Reveals Comet's Birthplace

One of the four NASA rocket missions to study comet Hale-Bopp during its 1997 sunward passage, EUVS, which stands for Extreme Ultraviolet Spectrograph (see "It's Only Rocket Science," October 1997), has revealed evidence that the ices in this unusually bright comet probably formed in the region near or beyond Neptune, and not closer in.

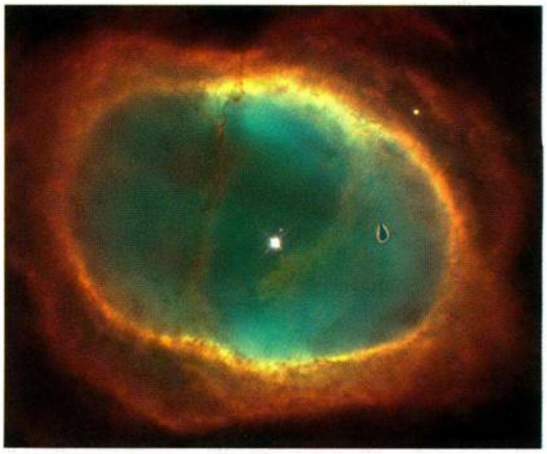
The evidence comes from EUVS's spectrometer, which detected argon gas. This detection of argon, the first noble gas discovered in a comet, opens a new realm of study because argon, like other noble gases, indicates a comet's thermal history. Noble gases vaporize at extremely low temperatures, so their presence in a comet suggests it must have been very cold where it formed.

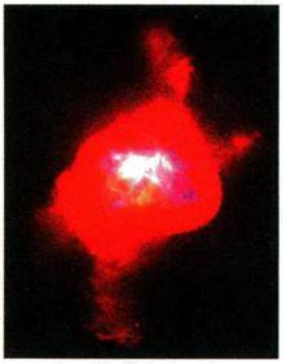
Based on the amount of argon detected, our team concluded that the ices that vaporized during Hale-Bopp's passage probably formed at temperatures below about 35 kelvins (35° C above absolute zero). But another team, led by Vladimir Krasnopolsky of NASA's Goddard Space Flight Center, failed to detect another noble gas, neon, with the Extreme Ultraviolet Explorer satellite. This indicates that the comet almost

(see "Rocket Reveals," p. 32)

A NASA rocket experiment indicates that comet Hale-Bopp formed in the region near or beyond Neptune. Loke Kun Tan

HUBBLE SPACE TELESCOPE





PLANETARIES UP CLOSE AND PERSONAL. New images made with the Hubble Space Telescope show the cocoons of gas enshrouding sun-like stars that have reached the ends of their lives. Hubble's image of the Southern Ring Nebula (right), NGC 3132 in Vela, reveals wisps of gaseous filaments being ejected from the star at 30,000 miles (50,000 km) an hour. Bluish gas is the hottest and red the coolest. This image was taken in 1995 and released as part of the Hubble Heritage Program. The image of the Turtle Nebula (left), NGC 6210 in Hercules, was taken in August 1997. The turtle shape measures 1.6 light-years from top to bottom. Holes in the inner shells of gas allow jets of hot material to stream away from the nebula in opposite directions. ABOVE: Hubble Heritage Team (STScI/AURA/NASA), LEFT: Robert Rubin (NASA/Ames), et al., and NASA

(Photons)

capability of even one of our single detector elements already outperform existing instruments," says physicist Blas Cabrera, leader of the Stanford team. "Of course there is a lot of work to do before this technology becomes a reality, but it already looks quite exciting."

The device, called a superconducting transition-edge sensor (TES), consists of squares of tungsten film about the width and length of a human hair. When physicists cool the squares to just 0.08° C above absolute zero, the tungsten becomes superconducting, meaning it carries electric current with no resistance. The tungsten's transition between a superconducting metal and an ordinary one is exceptionally sharp and is achieved when a single light photon falls on the tungsten square, causing it to heat up slightly. The amount of heating, measured as a brief change in the metal's conductivity, is proportional to the energy of the incoming photon.

"By providing information about the energy of a photon and the time when it arrives, these detectors can provide important information about some of the key unanswered questions in astronomy," says Stanford astrophysicist Roger Romani.

The team, which was conducting initial astronomical experiments in the fall of 1998, described their results in the August 10, 1998, *Applied Physics Letters*. — REX GRAHAM

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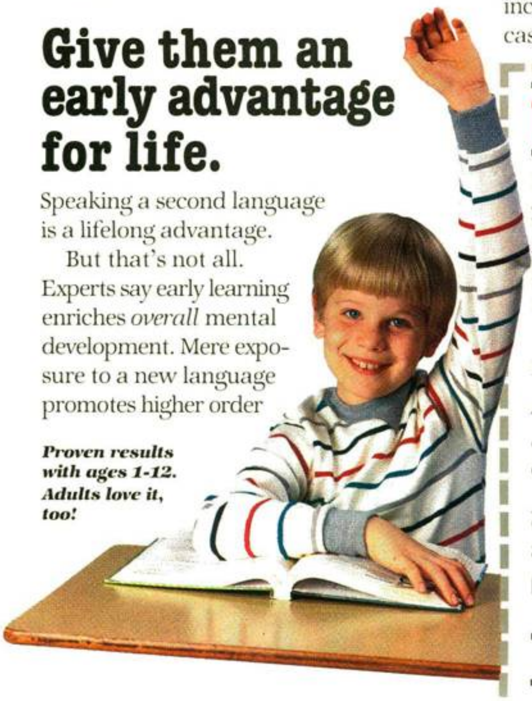

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(Rocket Reveals)
certainly originated in a region where temperatures exceeded 20 kelvins.

Based on these two temperature constraints, Hale-Bopp must have originated much farther out than the orbits of Jupiter and Saturn, most likely in the region at or beyond Neptune's orbit. With this new evidence in hand, planetary scientists can now better relate the chemical signatures of Hale-Bopp to a specific region in the young solar nebula. Over the next decade, space missions such as NASA's Deep Space 1 comet flyby and the NASA/ESA Rosetta comet orbiter should detect or set limits on noble gas abundances in several more comets. — ALAN STERN, SOUTHWEST RESEARCH INSTITUTE

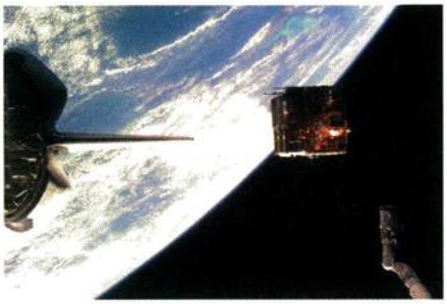
SOLAR OBSERVATORIES

Sun Shines on SOHO and Spartan

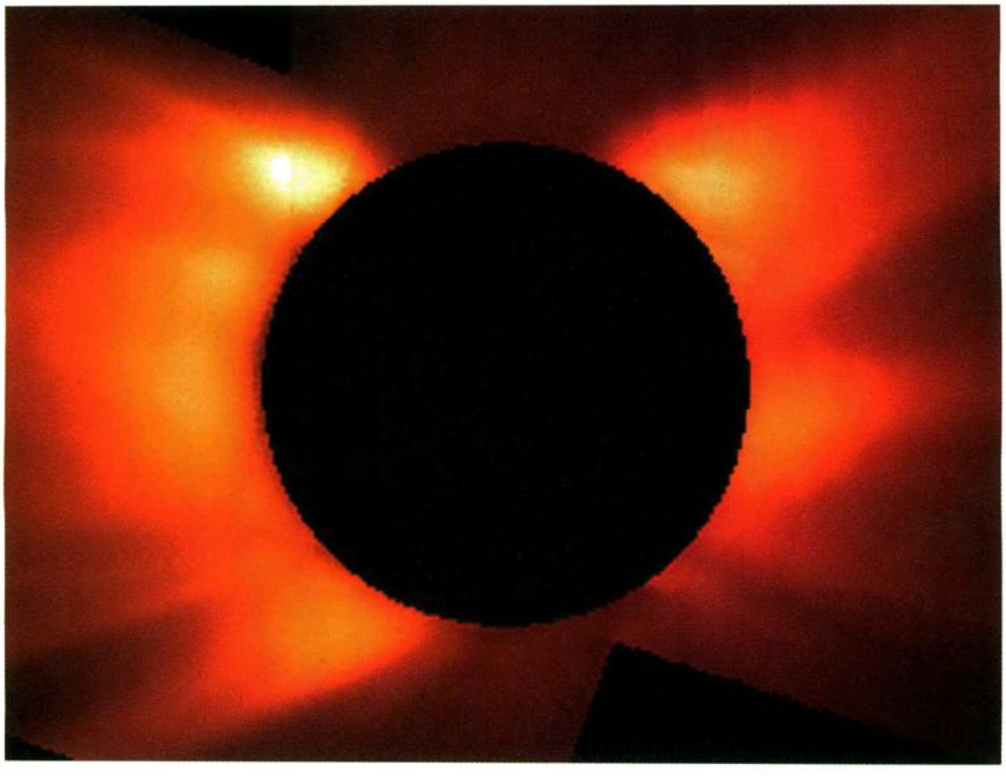
▶ After being nearly lost in space for four months, the $1-billion Solar and Heliospheric Observatory (SOHO) is revealing the sun's secrets once more. In mid-October 1998, two of SOHO's 12 scientific instruments, the Michelson Doppler Imager (MDI) and Extreme-ultraviolet Imaging Telescope (EIT), took the spacecraft's first pictures since June 24.

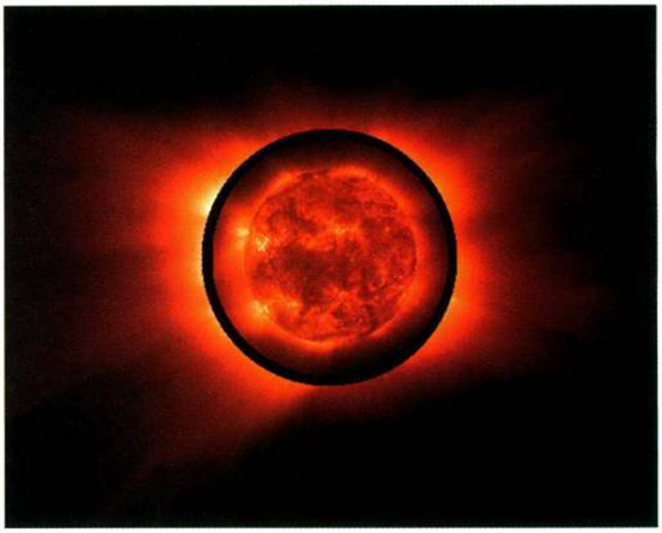
As of November 5, 1998, all 12 instruments had been switched on and recommissioned, and except for a slight degradation in one instrument, all were functioning as they were before the loss of contact. Scientists and engineers were astounded by the lack of damage. While out of commission, SOHO's onboard instruments experienced extreme temperatures. Some were as high as 210° F (100° C) and others as low as –150° F (–100° C); even the spacecraft's fuel tanks froze. "I tip my hat to the engineers who built this spacecraft and these sensitive but robust instruments," says Bernard Fleck, the

(see "SOHO," p. 34)



The Space Shuttle Discovery deployed the Spartan 201-05 satellite on November 1, 1998 (right). During the satellite's two-day flight, one of its instruments snapped this image (below) of the solar corona. NASA/GSFC





As this October 31 composite image (above) testifies, SOHO is back in business. NASA/ESA

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(SOHO) European Space Agency's project scientist for SOHO.

In another solar success story, Space Shuttle Discovery astronauts on STS-95, the mission with John Glenn, successfully deployed and retrieved the Spartan 201-05 satellite. This 3,000-pound (1,400 kg) spacecraft, which is about the size of a compact car, imaged the sun in visible and ultraviolet light. Scientists will study Spartan's images and data to better understand the corona and the origins of coronal mass ejections, which give rise to space weather (see "Blowin' in the Solar Wind," October 1998). — ANDREA GIANOPOULOS

ASTROBIOLOGY

Life Scarce on Mars?

▶ If life ever got started on Mars, it was probably extremely rare and may never have evolved past a primitive state, say geochemists Bruce Jakosky of the University of Colorado and Everett Shock of Washington University in St. Louis, Missouri.

In a study described in the August 25, 1998, *Journal of Geophysical Research*, the two scientists claim that the modest amounts of geochemical energy on Mars over the last 4 billion years could have supported only a small population of microorganisms. The scientists estimate a planetwide average of 20 grams of organisms per square centimeter at most. Earth's total is 4 million times that because our home planet is larger than Mars, so it retains more of its geochemical energy.

"Our estimate is most properly viewed as the biological potential from geothermal energy alone," stresses Jakosky. "If life ever did exist, the numbers would go up if photosynthesis evolved."

According to Jakosky and Shock, martian organisms would have obtained their energy at hydrothermal vents and hot springs. Although only indirect evidence exists for hydrothermal vents on Mars (see "Getting into Hot Water on Ancient Mars," AstroNews, September 1998), scientists do know the Red Planet once had volcanoes. On Earth, volcanoes often spur hydrothermal activity.

While the study relies in part on conjecture, it raises an important point: To find life, future sample-return missions to Mars should target regions that were once thermally active (see "Divining on Mars," page 42). "The best chance for success in our search for martian life is to go to the places where the most energy was available, where life would have had the best opportunity to thrive," says Jakosky. "Despite the difficulty of finding places where life could have existed and bringing back rock samples, I'm optimistic that we may be on the verge of discovering martian life." — TRACY STAEDTER

WEBSITE

Check *Astronomy*'s website for news as it happens — http://www.astronomy.com.

Shortcut to Mars

A round-trip journey to Mars that now takes three years could someday take as little as 45 days, says physicist Carlo Rubbia, winner of the 1994 Nobel Prize for physics. Rubbia has proposed a nuclear-powered ship that would rely on a synthetic isotope known as americium-242. Splitting apart americium atoms with neutrons generates ionized fragments that create intense energy when passing through hydrogen. In fact, one gram of americium can supply the same energy as one ton of conventional chemical propellant. Rubbia is currently working with Italian and European space agencies to make the spacecraft a reality.

AXAF Delayed Again

The launch of NASA's $1.3-billion Advanced X-ray Astrophysics Facility (AXAF) has been postponed for a second time due to technical problems at the satellite's main contractor, TRW Space and Electronics Group of Redondo Beach, California. AXAF was scheduled to launch on January 21, 1999, but it has been delayed until at least April. AXAF will be the third of NASA's four "Great Observatories." The first two, the Hubble Space Telescope and the Compton Gamma Ray Observatory, were launched in the early 1990s. The $460-million Space Infrared Telescope Facility (SIRTF) is still under construction.

AXAF undergoes testing in July 1998.

AXAF Science Center

Beam Me up, Scottie

Quantum teleportation, similar to Star Trek's far-fetched transporter technology, recently became a reality when physicists at Caltech transported a packet of energy from one point to another, one meter away. "This is an important step toward the realization of networks for distributing quantum information," said team member Samuel Braunstein. The Caltech group generated exotic forms of light which are split in such a way that the transmitter and receiver each get a beam that is the quantum mechanical "twin" of the other.

Georges Halts Winter Star Party

The 1999 Winter Star Party (WSP) has been canceled because of hurricane Georges damage to the star party's site, Camp Wesumkee. Tippy D'Auria, WSP founder and Chairman, promises star party goers that 2000 will be 'better than ever." If you just can't wait until then, the residents of the Chiefland Astronomy Village are opening their site to the community from February 14 to 21.

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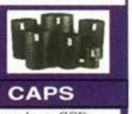

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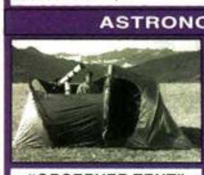

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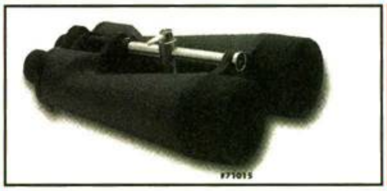

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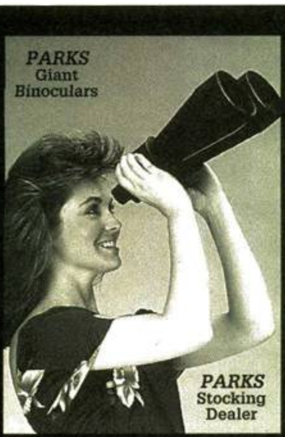
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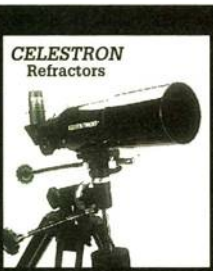
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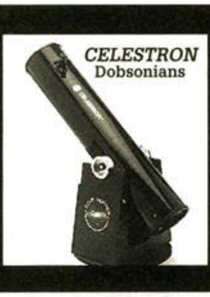
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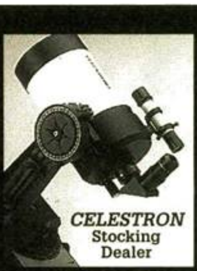
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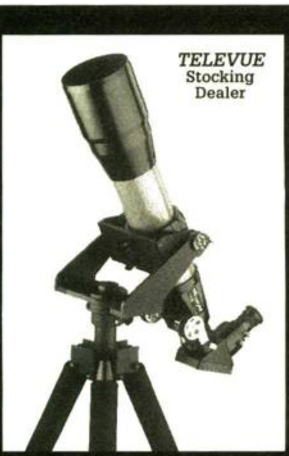
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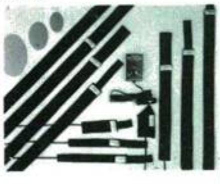

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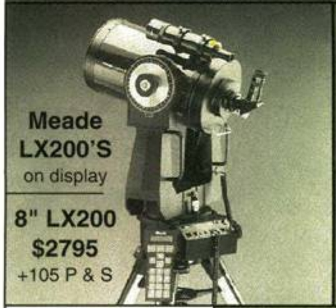

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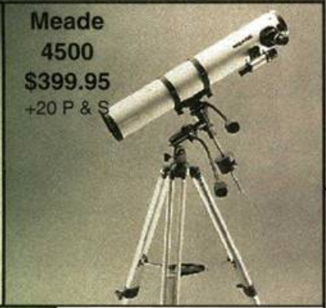

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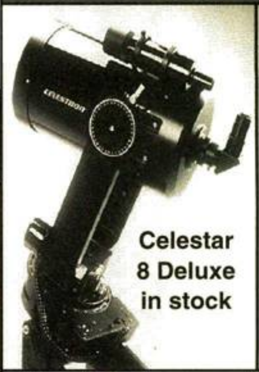

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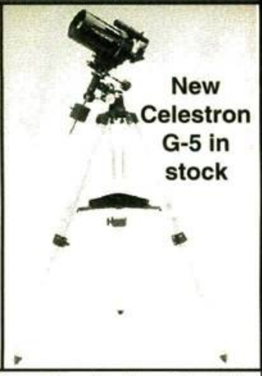

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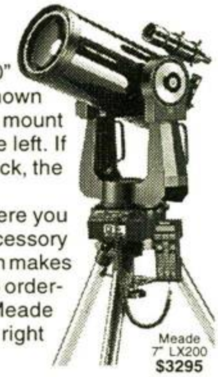

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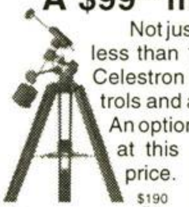

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Divining on Mars

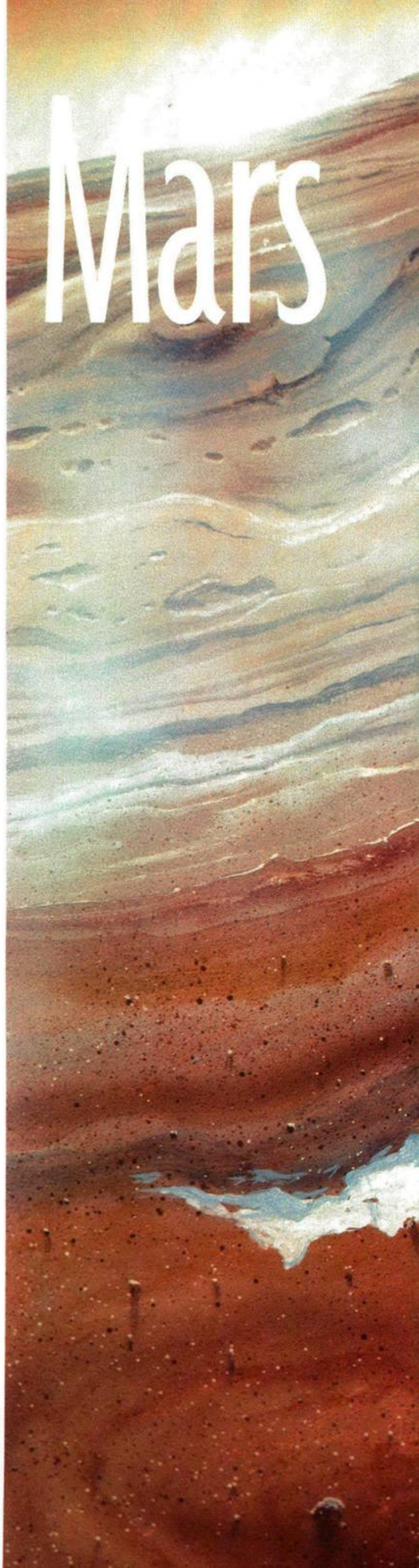
NASA is launching a martian orbiter and lander to find out what happened to the Red Planet's warmer and wetter climate.

by Michael Carroll

DESPITE OUR BEST PRODDINGS, PHOTOS, DIGGINGS, AND rovings, Mars tenaciously clings to some of the greatest mysteries in planetary science. Since 1971, spacecraft have radioed back thousands of images that hint at a Mars far wetter and warmer than the parched world we see today. But these images leave many questions unanswered: How much water flowed across the surface of ancient Mars? Where did the water go? Why did Mars's climate change? Could the same thing happen to our own world?

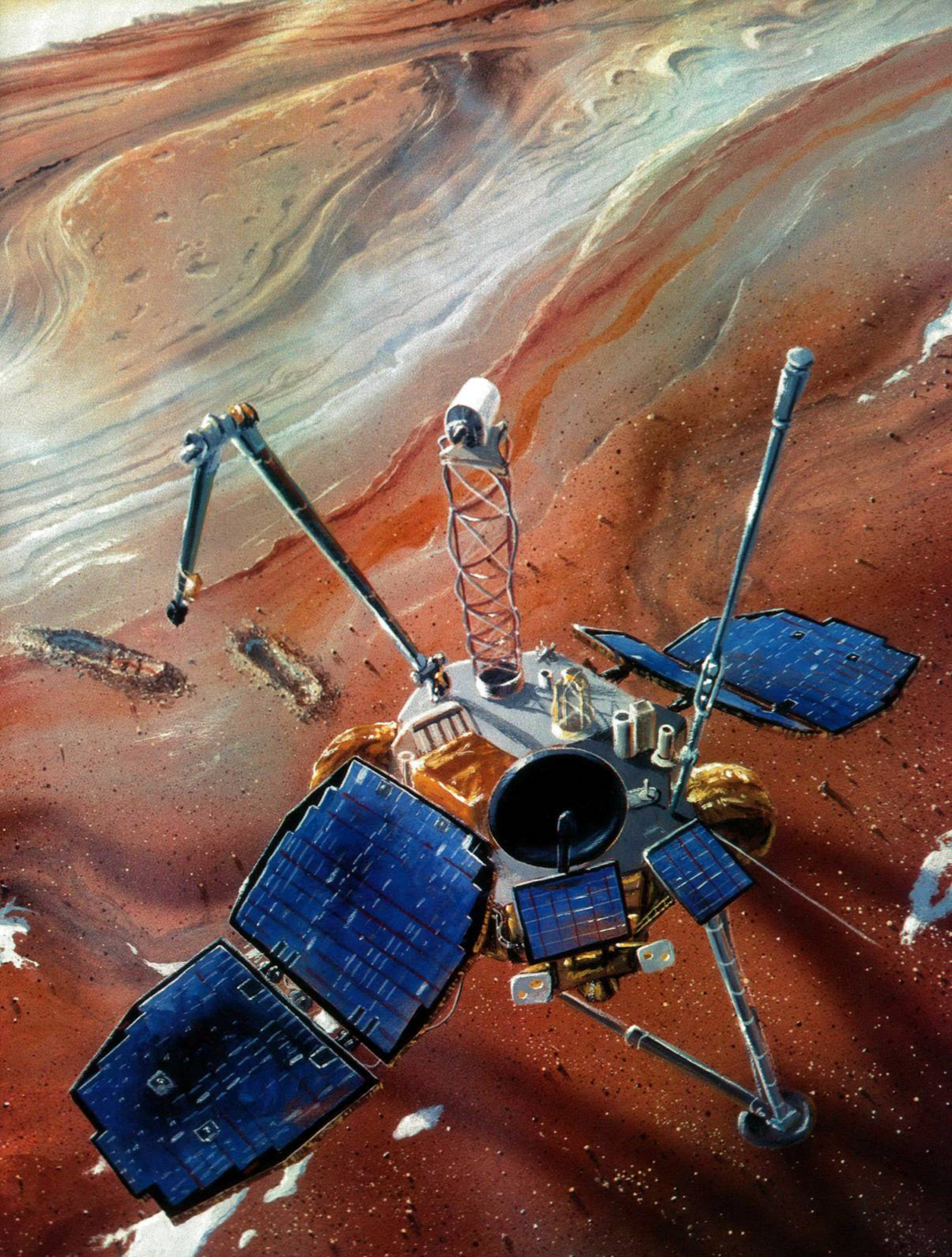
To investigate the current martian climate and the puzzling history of climate change, NASA is launching the next pair of missions to the Red Planet: Mars Climate Orbiter and Mars Polar Lander. These two missions, collectively known as Mars Surveyor '98, follow closely on the heels of Mars Pathfinder and Mars Global Surveyor, which represented the first shots in NASA's ongoing "faster, better, cheaper" Mars exploration program.

At press time, Mars Climate Orbiter was scheduled to blast off a Kennedy Space Center launch pad on December 10, 1998, and arrive at Mars in September 1999. Mars Polar Lander was slated for a January 3, 1999, liftoff. After an 11-month cruise, it will touch down near the martian south pole in December 1999, using parachutes and braking thrusters to slow its final descent. Just before entering the atmosphere, the lander will drop two instrument-laden penetrators, which will crash-land onto the martian surface at separate locations approximately 60 miles (100 km) north of the lander.



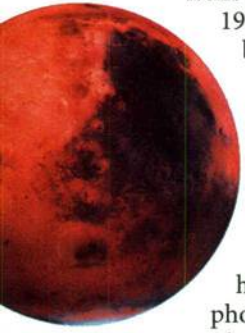
NASA's next Mars lander will touch down near the south pole in early December 1999, when it's late spring in Mars's southern hemisphere. The lander carries a 6.6-foot-long robotic arm, which will dig into the soil to look for water. The lander should function for three months before the batteries freeze.

Michael Carroll



Where's the Water?

When they reach their destination, Mars Climate Orbiter and Mars Polar Lander will find a desolate planet whose surface is drier than the driest deserts on Earth. Mars's thin air doesn't supply enough pressure to support liquid water, which boils away almost instantly into the salmon-colored sky. Rivers have not flowed on Mars, nor have rains fallen there, for billions of years.



But Mars wasn't always such a dry place. Orbital photos from the Mariner 9 and Viking 1 and 2 missions of the 1970s revealed branching canyon systems and large, braided channels that closely resemble terrestrial river valley networks and flood channels. Planetary scientists almost unanimously agree that liquid water carved these martian canyons billions of years ago, meaning the Red Planet must have once had a thicker carbon dioxide-rich atmosphere that warmed the surface.

Mars Pathfinder and Mars Global Surveyor have added support to this picture. Pathfinder photographed stacked boulders, which were almost certainly deposited by rampaging flood waters. Mars Global Surveyor's high-resolution camera has imaged river-like gorges, layered sediments that may be related to standing water, and possibly even dry lake beds. Its infrared spectrometer has discovered the first clear evidence of an ancient hydrothermal system, implying that stable water remained at or near the surface for long periods of time early in martian history.

But perhaps Mars Global Surveyor's most dramatic result has come from the laser altimeter, which shows that the plains covering most of Mars's northern hemisphere are flatter than Kansas for thousands upon thousands of miles. "These broad expanses could be the long hypothesized ocean, covered over with sand dunes and lava flows," says Jeffrey Kargel of the United States Geological Survey in Flagstaff, Arizona. "What I'm most excited about is the possibility that the ocean is still there beneath the surface, either an ocean of frozen water or an ocean of mud."

Such an ocean would be an incredible natural resource for future human explorers, and it could imply past or even present life on Mars. But scientists still don't know if such an ocean ever existed, or if it did, how much water it contained. The water has vanished from the surface, and why it disappeared is one of planetary science's most profound mysteries. The amount of water detected in Mars's atmosphere and polar caps is nowhere near enough to explain the variety of geological features. Some of Mars's original water may have escaped into space, but much of it could still be there — locked up as ice in the crust.

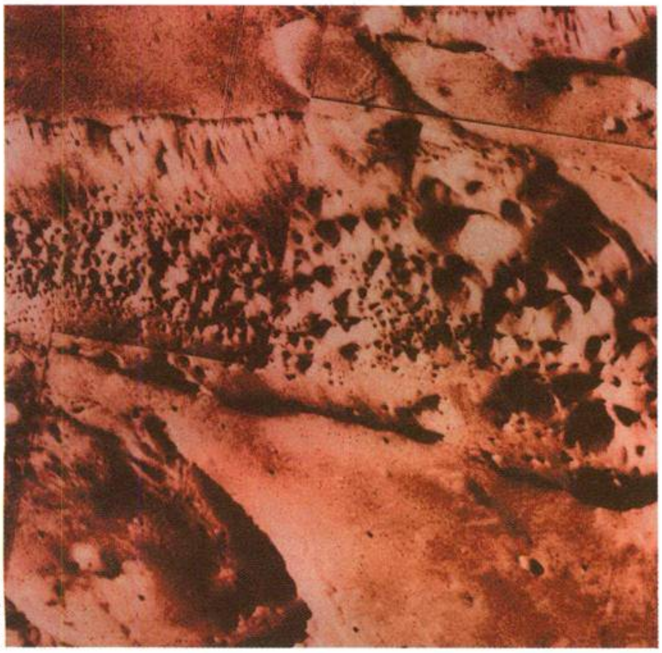
A Mars Weather Satellite

The Mars Surveyor '98 missions were designed to address these questions. Mars Climate Orbiter's role is to monitor Mars's weather on a daily basis for a full martian year — equivalent to almost two full Earth years. The orbiter will also provide a communications link between Earth, Mars Polar Lander, and future surface robots.

The spacecraft carries a spare of one of the instruments aboard NASA's ill-fated 1993 Mars Observer mission, the Pressure Modulator Infrared Radiometer (PMIRR). This instrument records the amount of dust and the temperature in the atmosphere as a function of altitude. The amount of airborne dust controls how much solar heat is absorbed by the atmosphere. The warmer the atmosphere, the more water vapor it can hold. Combining these results with data about humidity and water-ice clouds, researchers hope to nail down the present climate picture and better understand how water and carbon dioxide shuttle back and forth between the atmosphere and the polar regions over the course of a seasonal cycle.

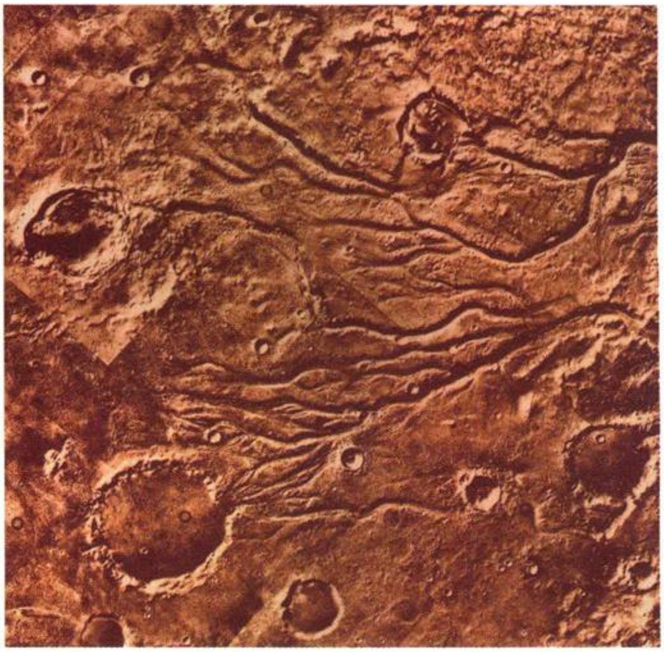
The orbiter also carries an imaging system built by Malin Space Science Systems of San Diego, California, the company founded by geologist Michael Malin that is bringing us the

This Viking image shows a canyon that probably formed when subsurface ice suddenly melted and gushed to the surface in a torrential flood.



NASA/JPL

These branching valley networks, seen in a Viking 1 orbiter image, were almost certainly carved by running water billions of years ago.



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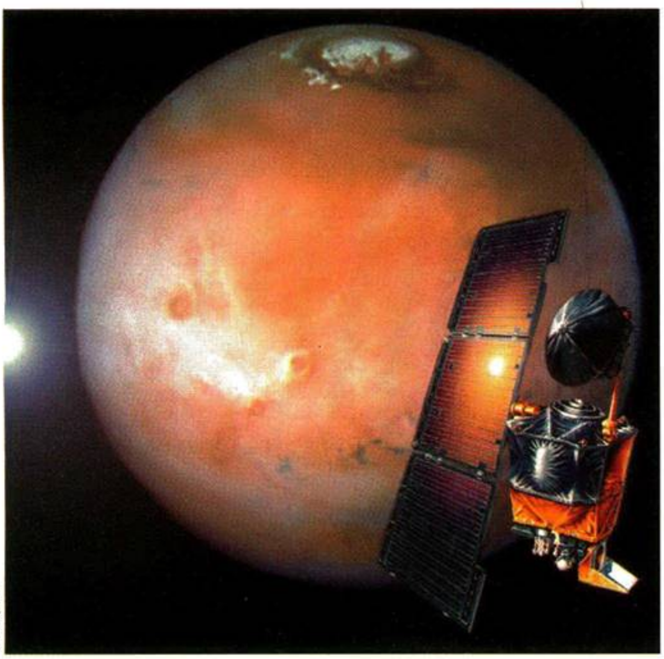

NASA/JPL

Mars Climate Orbiter will function as a weather satellite for a full martian year — the equivalent of almost two Earth years.

USGS

A mid-course rocket firing in July will aim Mars Polar Lander toward its exact landing site near the edge of Mars's south polar cap.

beautiful Mars Global Surveyor images. Mars Global Surveyor's cameras were designed to take high resolution views in one color. The Mars Color Imager (MARCI) aboard Mars Climate Orbiter will obtain only low and medium resolution pictures, but in many colors, enabling it to identify atmospheric features as well as sense color variations on the surface. MARCI weighs only 5 pounds (2.2 kg) and is as small as a pair of hand-held binoculars.

The information gleaned from the orbiter about Mars's present-day climate will prove crucial for understanding the past climate. "We're using the seasonal change as a proxy for climate changes that occurred over much longer periods of time," says Richard Zurek of the Jet Propulsion Laboratory, the Mars Surveyor '98 project scientist. "If we can model the physical processes correctly, then we can extrapolate those back into the past."

More than Skin Deep

Mars Polar Lander will touch down near the northeast boundary of the "layered terrain" that surrounds the south pole, between a latitude of 75° and 78°. The layered terrain is unique to Mars's polar regions and appears from orbit to be terracelike layers of frost interspersed with layers of dust. Mars's seasonal dust storms are thought to deposit a thin veneer of dust on the polar caps. As winter advances, carbon dioxide and water ice coat the dust. Over eons, many layers build up and are then sculpted by the wind into linear features that snake across the polar wilderness for hundreds of miles. Orbital images show layers roughly 160 feet (50 meters) thick, which were probably deposited during warm and cold spells lasting tens of thousands of years. "These layers preserve a record of Mars's climate history," says Ralph Lorenz of the University of Arizona, who works with both the lander and penetrator mission science teams.

Scientists don't know what this alien environment will look like from the surface, but it should appear dramatically different from the Viking and Pathfinder sites. The lander will arrive in the southern hemisphere's late spring, when carbon dioxide ice in the southern polar cap is turning into vapor. "We will see frost and maybe fog," predicts Lorenz. Mars Polar Lander should function for at least 90 days on the martian surface before the batteries freeze.

The lander's primary instrument package, Mars Volatiles and Climate Surveyor (MVACS), is not designed to search for life. But it may find clues as to whether past conditions were favorable for life. MVACS will do this by searching for volatiles — substances such as water and carbon dioxide that can move around a planet by evaporating in one place and condensing into a solid in another. MVACS consists of a 6.6-foot-long (2 meter) robotic arm, a stereo color imager similar to the one aboard Pathfinder, an advanced meteorology boom, and a complex experiment known as Thermal and Evolved Gas Analysis (TEGA).

The robotic arm is the first to visit Mars since Viking. Designed and built by NASA's Jet Propulsion Laboratory, the arm has been integrated into the rest of the spacecraft by the lander and orbiter's prime contractor, Lockheed Martin Astronautics in Denver, Colorado. "The robotic arm will be able to dig almost a meter down if the soil is soft enough. It has an elbow and shoulder joint, so it is a much more capable system than the one Viking had," says Lockheed Martin's Ed Euler, program director for Surveyor '98. The arm also has a camera on the end that can resolve individual grains of sand.

The robotic arm will deliver up to eight soil samples to TEGA. An oven will cook the samples, freeing gases and water trapped inside. A laser spectrometer will detect the gases that are driven off. Thermal changes will indicate water-bearing minerals that may have formed during periods when there was liquid water on Mars.

David Paige of UCLA, MVACS's principal investigator, says the landing site was chosen for one overall reason: temperature. "It's cold down there; temperatures will average around –100° F (–72° C). Because of that, we have a better chance to actually touch volatiles with the lander. They are likely to be concentrated at these high latitudes, and they should be near the surface." Based on the amount and depth of any water ice that MVACS finds, scientists should be able to infer how much water is locked up in the soil over the entire planet, which in turn will shed light on how much liquid water existed in the past.

Besides looking for volatiles, MVACS could see evidence of layering in the one-meter-deep trenches excavated by the robotic arm. If scientists are correct in estimating the rate at which ice and dust are being deposited in the polar regions, one meter of sediment should correspond to a 100,000-year record of climate change on Mars. In a best case scenario, the robotic arm's high-resolution imager will see fine-scale annual layering reminiscent of tree rings.

Mars Polar Lander will differ from Mars Pathfinder in one other major respect: No rover will be tagging along. "There are two ways to explore the surface of Mars," explains Mars Surveyor '98 project manager, John McNamee of JPL. "If you're looking for rocks, the best way to go is horizontally, and a rover is the right thing to do that. But if you're looking for water and climate history, digging straight down is the way to go."

As it's parachuting to the surface, Mars Polar Lander will take what could be spectacular images of the surrounding terrain with the Mars Descent Imager (MARDI), giving scientists a geological and physical context for the lander's immediate vicinity. Once on the ground, MARDI will resolve tiny soil particles directly below the lander.

The Russian Space Agency has supplied the Light Detection and Ranging (LIDAR) instrument, which will bounce laser pulses off clouds to determine their composition and measure atmospheric dust content. LIDAR is the first Russian-built instrument to fly aboard an American planetary mission.

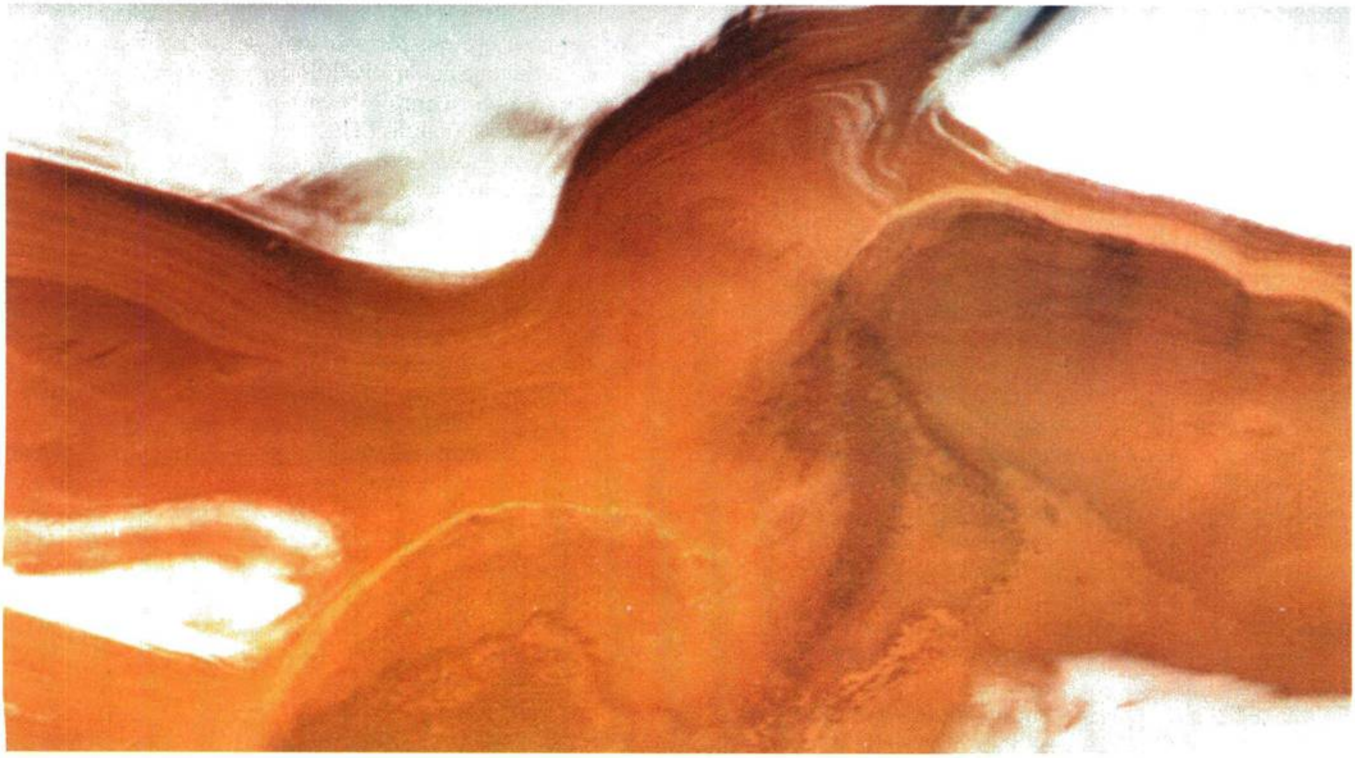
The Planetary Society and Caltech have devised a palm-sized microphone to pick up sounds audible to the human ear as well as some lower frequencies. According to the Planetary Society's executive director Louis Friedman, the device will be able to hear "machinery, wind, dust blowing against rocks, and who knows what else."

The two 5.5-pound (2.7 kg) penetrators piggybacking on Mars Polar Lander will fit inside basketball-sized aeroshells. They will be released just prior to the lander's atmospheric entry. With no parachutes or braking thrusters, these microprobes will slam into the surface at roughly 450 miles (700 km) per hour and bury themselves up to 3 feet (1 meter) deep. Part of the NASA/JPL New Millennium project to develop miniaturized spacecraft for the 21st century (see "Deep Space 1 Set for Asteroid Visit," page 57), the "Deep Space 2" microprobes carry a simplified version of TEGA to look for water ice underground. They will also measure soil temperatures and look for layers in the soil. The probes are designed to function for one to three days.

"Ultimately you could launch fleets of these things," says Deep Space 2 project manager Sarah Gavit of JPL. "You'd have one mother ship with 10 or 15 penetrators. You could disperse them across a planet and get data from different locations, which is important if you're trying to understand the meteorology of the planet or its seismic activity."

The truly remarkable aspect of Mars Surveyor '98 is its size, or lack thereof. The lander weighs in at 1,250 pounds (570 kg), roughly half a Viking lander and about two-thirds Pathfinder's weight. The orbiter is the size of a telephone booth and weighs only 1,400 pounds (630 kg). Cost is another difference. "On the Viking project we spent billions and billions in today's dollars to do this kind of thing. This

Mars Polar Lander will use its robotic arm to dig several feet deep into the layered terrain of Mars's polar regions, seen in this Viking 2 image.



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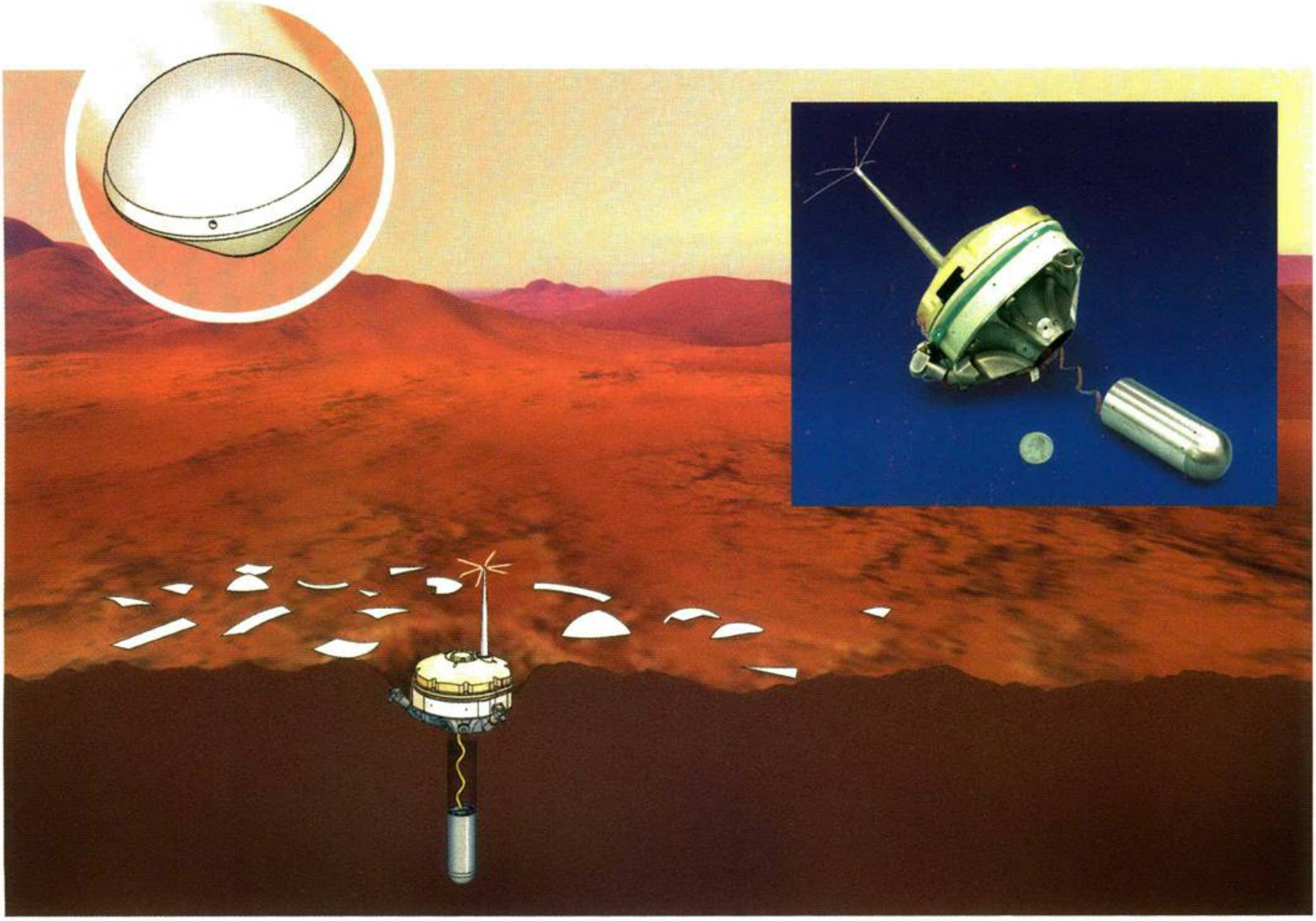

Astronomy: Rick Johnson

When Mars Polar Lander enters Mars's atmosphere, it will drop two 5.5-pound penetrators (upper right). The Deep Space 2 probes will free-fall inside basketball-sized aeroshells (upper left), which will slam into the surface at about 450 miles per hour and bury the penetrators 3 feet deep.

Surveyor program is very advanced, and phenomenally inexpensive," says Euler. The entire cost of the Mars '98 orbiter and lander development is $184 million, approximately the same as the Pathfinder lander alone when inflation is taken into account.

Future Expeditions

While Mars Climate Orbiter and Mars Polar Lander open new doorways into the martian past, other explorers will be readied for the next launch windows, which occur every 26 months. NASA's current plans call for an orbiter and lander to launch in 2001 and landers in 2003 and 2005. The 2001 orbiter will map element and mineral deposits across the globe, detecting areas where water may still be preserved near the surface. Another instrument will use infrared spectrometry to search the planet for future high-priority landing sites.

The 2001 lander will carry a sensor that measures the radiation threat to future human explorers. It will also analyze surface dust for acidity, electrical conductivity, and toxic chemicals — potential hazards to astronauts. Another experiment will attempt to manufacture oxygen from the martian atmosphere to see if it can be "mined" for propellants for future manned missions. The lander will bring along a rover that's virtually an identical twin of Mars Pathfinder's Sojourner.

As currently conceived, the 2003 lander will include the rover Athena, under development at Cornell University and JPL. This rugged six-wheeler will be a much larger and more sophisticated version of Sojourner. Athena will range up to 1,000 feet (300 meters) from the lander, collecting samples and drilling into rocks. Specimens will be analyzed on site, and some will be stored for possible return to Earth. While Pathfinder's vehicle was designed for a seven-day stint, Athena may last a full year, storing up to 91 rock and 13 soil samples. A microscopic imager will reveal details in rocks and soil. "Athena is a huge jump over the Sojourner-class rovers," says Cornell planetary scientist Jim Bell.

While NASA has no plans for a 2003 orbiter, the European Space Agency has recently approved funding for an ambitious 2003 orbiter called Mars Express. NASA, working with Italy's space agency, may provide a radar system to look for subsurface water. One of several European scientific groups may provide a small lander to accompany the orbiter.

The 2005 mission brings the ultimate payoff: the launch of a sample-return mission. As currently conceived, samples from the 2003 rover and a 2005 Athena-class rover will be launched into Mars orbit, where they will be collected by a French-built orbiter and then returned to Earth in 2008. With samples in hand and half a dozen missions under their belts, scientists hope to finally answer the question of what happened to the martian climate and what it means to us on this fragile blue world.

Michael Carroll frequently contributes articles and paintings to Astronomy. *His children's book about the planets,* Spinning Worlds, *can be ordered from his website at www.power-online.net/~spaceart.*

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by Richard Kron and Sharon Butler

The Sloan Digital Sky Survey will tell astronomers how the universe evolved.

SINCE THE THIRD MILLENNIUM B.C., HUMANITY HAS been charting the heavens, naming constellations, and pondering their effects on Earth. But it was not until technology supplanted the naked eye that astronomy opened up unimagined worlds.

Now for the first time, astronomers are using digital technology to chart the sky. The ambitious $77 million Sloan Digital Sky Survey has just gotten underway, and the expectations for scientific discoveries are high.

The survey involves a collaboration of more than 130 scientists, engineers, and computer professionals from eight American and Japanese research institutions. The team has built a state-of-the-art 2.5-meter telescope at the Apache Point Observatory in New Mexico to map one-half of the northern sky. Sloan astronomers will survey a volume of space 100 times larger than any ever charted before, reaching out 1.5 billion light-years to collect digital images and reams of data on the position, size, shape, color, and brightness of every galaxy in that region. Scientists all over the world expect to learn more about the stars and galaxies that populate our night sky and to answer still deeper questions about how the universe evolved since the Big Bang.

University of Chicago astrophysicist Michael Turner, a member of the collaboration, expects the survey to "play a role in almost every important astronomical discovery in the next half century." Sloan project director Jim Crocker agrees. He calls the five-year enterprise not just a survey, but a "science machine."

The last such field guide to the northern heavens was the National Geographic Society-sponsored Palomar Observatory Sky Survey, completed in the 1950s when the technology was limited to photographic plates. The Palomar Survey, recently digitized, has long served as a resource for astronomers. A newer version is nearing completion (see "Palomar Rides Again," page 51). But Sloan will provide unprecedented depth and detail, and three dimensions of data instead of two.

AS STARS DRIFT BY

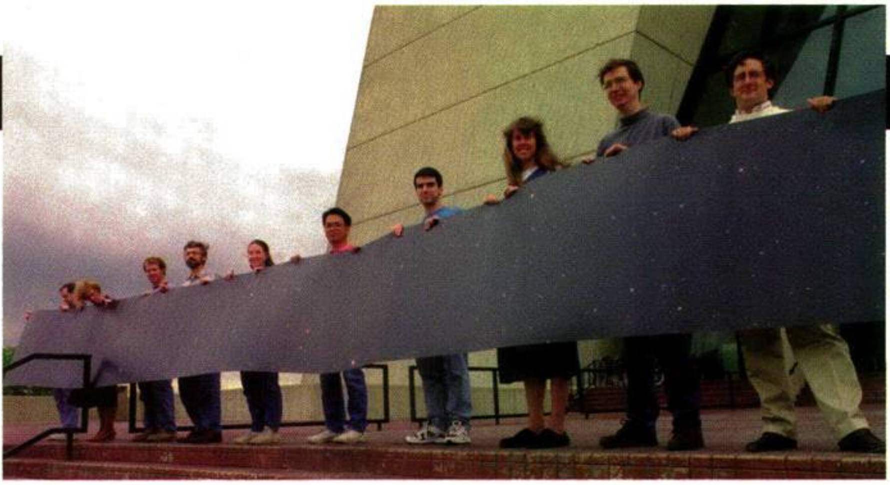
The Sloan Survey is actually two projects in one: an imaging survey and a spectroscopic survey. On each moonless night when the "seeing" is good, a

The frame from the Sloan Digital Sky Survey (upper left) shows dust clouds against a starry backdrop. Fermilab Visual Media Services custom-made $5 million digital camera — the largest and most complex astronomical camera ever built — will collect images of a million celestial objects, 100 million over the course of the study. The camera photographs the sky as it drifts by with Earth's rotation, creating long strips of starry images.

Weighing more than 700 pounds (300 kg), the Sloan camera has a light-sensitive area that consists of an array of 54 silicon light detectors called charge-coupled devices (CCDs), similar to CCDs found in camcorders. The huge size of the light-sensitive area — about the same as a small table — is roughly 100 times that of a typical professional astronomy camera.

The large array gives the camera a 3° field of view (the width of six full moons), meaning it covers as much sky as a backyard finder scope — but with a million times the sensitivity. The wide field will enable the project to cover a full quadrant of the sky in about five years; conventional cameras and telescopes would require 500 years to do the same job. The Sloan camera has a resolution of 0.4 arcsecond. Imaging the sky with that kind of resolution is like mapping Earth with detail fine enough to show not just cities and mountain ranges, but individual houses.

The Sloan pictures are taken in five colors, or wavelengths: ultraviolet, green, red, and two infrared bands. The multiple colors enable astronomers to sort out the bewildering variety of stars, quasars, and other objects in each picture. The disk of our own Milky Way Galaxy is filled with stars and dust, but the Sloan astronomers are primarily interested in objects beyond our galaxy. To avoid the crowded Milky Way star fields, the telescope will peer at the northern sky in the direction well above the galactic plane. The survey will capture every object down to 23rd magnitude within this large region of sky.

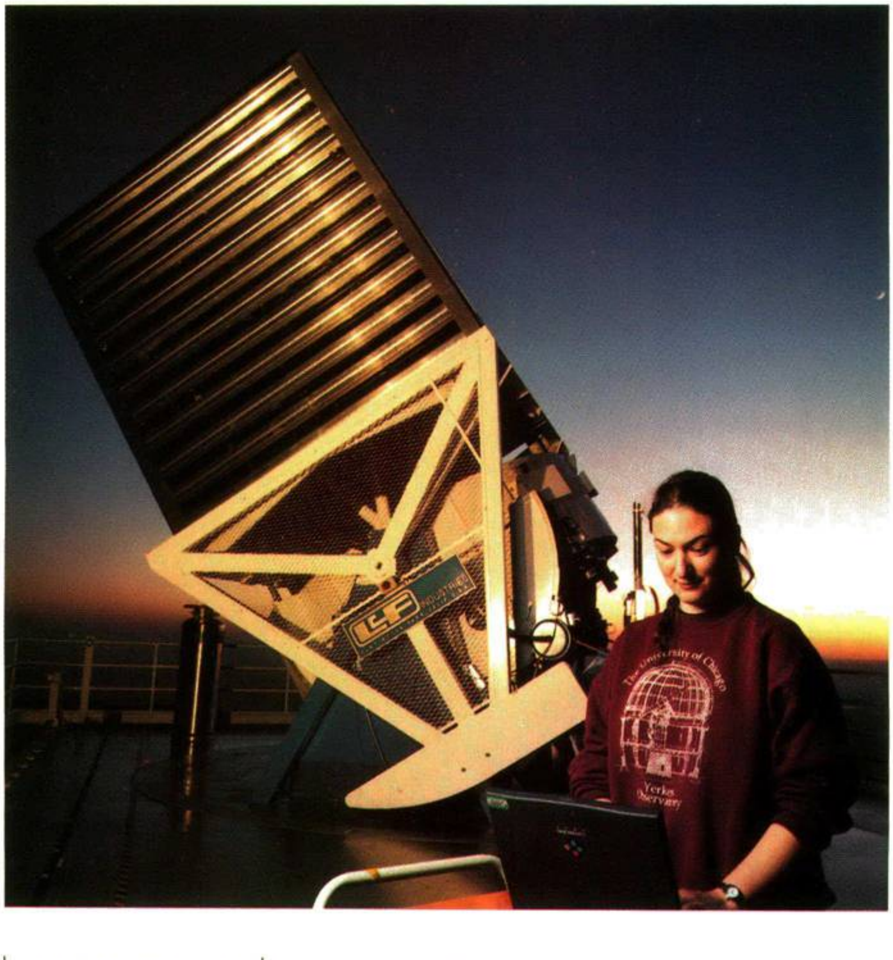


Sloan Digital Sky Survey workers display one of the first strips taken by the project. They are standing at the entrance of Fermilab.

Fred Ullrich/Fermilab Visual Media Services

On nights when conditions are adequate but less than optimal, the second part of the survey kicks in. This project will take spectra to create three-dimensional maps of the entire quadrant. The camera is tucked away in a garage, and two spectrographs, fed with hundreds of optical fibers, will record the wavelengths of light emitted by galaxies, quasars, and stars seen in the imaging survey. Altogether, astronomers will obtain a million spectra of the brightest galaxies and 100,000 quasars (roughly 100 times more quasars than in any other single survey). Up to 640 spectra can be recorded simultaneously, and 5,000 can be taken on a good night.

Astronomers can calculate the distances to these galaxies and quasars by measuring the redshifts of their spectra. The farther away they are, the faster they are receding in our expanding universe, and the more their light is shifted toward the red end of the



University of Chicago astronomer Constance Rockosi, a member of the team that built the Sloan camera, checks the survey's instrumentation. The project's 2.5-meter telescope stands behind her. Fermilab Visual Media Services

spectrum. The spectra will also reveal the velocities of stars within galaxies, which will tell astronomers the amount of underlying mass. Astronomers will also glean information about chemical abundances and glowing gas clouds from the spectra.

Alternating the imaging and the spectrographic studies will make the survey more efficient, almost halving the time it might have taken to finish the project. Astronomers normally finish a photographic survey before returning to record redshifts. In the Sloan project, however, data from the camera's scans will be processed immediately in the computing facilities at Fermilab, in Batavia, Illinois, and spectroscopic targets will be selected within a few days.

The survey will acquire at least 12 trillion bytes of data, rivaling the information content in the 111 million books and periodicals stored in the Library of Congress. Eventually, the Sloan Digital Sky Survey's catalog of objects in the sky, along with images, will be available for scientists, amateur astronomers, students, and teachers all over the world so that anyone can try to tease out information. By coupling the Sloan catalog with data from other new surveys being conducted at ultraviolet, infrared, and radio wavelengths, scientists may in time create what Johns Hopkins University astronomer Alex Szalay calls "the dial-up sky." Says University of Washington astronomer Bruce Margon, "Astronomers will have a permanent digital encyclopedia of the sky — they will solve problems by going to the archive rather than to a telescope."

A MAP OF SPACE AND TIME

With the Sloan Digital Sky Survey's phenomenal resolution and huge sample size, it will be able to catalog not only run-of-the-mill stars and galaxies, but rare objects as well — such as asteroids with peculiar orbits or intergalactic clouds with relatively large abundances of heavy elements. More importantly, astronomers and cosmologists should be able to better

PALOMAR RIDES AGAIN

With its state-of-the-art telescope, digital camera, and dual spectrographs, the Sloan Digital Sky Survey will forge a new era in the observational study of the universe. But the old era won't soon pass away. "There is a tendency," says Caltech astronomer Neill Reid, "to think that Sloan will automatically make everything else obsolete." The newly updated Palomar Observatory Sky Survey will soon lay those thoughts to rest.

Conceived half a century ago by Edwin Hubble, Fritz Zwicky, Walter Baade, and other luminaries of the era, the original Palomar survey was designed to complement the new 200-inch Hale Telescope, in part by finding interesting targets for the glass giant. Completed in 1958, the photographic survey has played a vital role in innumerable astronomical breakthroughs, among them George Abell's catalog of 2,712 clusters of galaxies that helped sketch the large scale structure of the universe.

By the 1980s, dramatic improvements in the resolution and sensitivity of photographic emulsions made the idea of a second survey attractive. The Palomar Observatory Sky Survey II uses the same telescope — the 48-inch (1.2-meter) Oschin Schmidt Telescope on Palomar Mountain — as the first, but will cover the entire northern sky in three colors (blue, red, and near-infrared) instead of two and with approximately three times better resolution. The survey began in 1985 and is nearing completion: As of November 1998, all of the blue plates, 97 percent of the red plates, and 83 percent of the near-infrared plates were finished.

What role will the Palomar survey play in the Sloan era? Although Sloan goes deeper and takes images in five colors instead of three, Palomar covers *all* of the sky north of the celestial equator instead of one-half. This all-sky coverage means astronomers can study the structure of the Milky Way Galaxy in detail, something Sloan won't do because it avoids the dense star fields of the Milky Way. And by comparing the new survey with the old, researchers will accurately measure the motions of more than a million stars over a five-decade time span, revealing the galaxy's dynamics near the sun. Other astronomers will continue to probe the large scale structure of the universe by cataloging galaxy clusters, quasars, and low-surface-brightness galaxies. Still others will use the red and near-infrared plates in conjunction with the 2MASS infrared survey to search for low-mass stars and brown dwarfs.

Yes, a brave new era is upon us, with Palomar and surveys at other wavelengths joining Sloan to lead the way. — *Richard Talcott*

The new Palomar Sky Survey covers the entire northern sky, including rich Milky Way fields such as this one in Cassiopeia.

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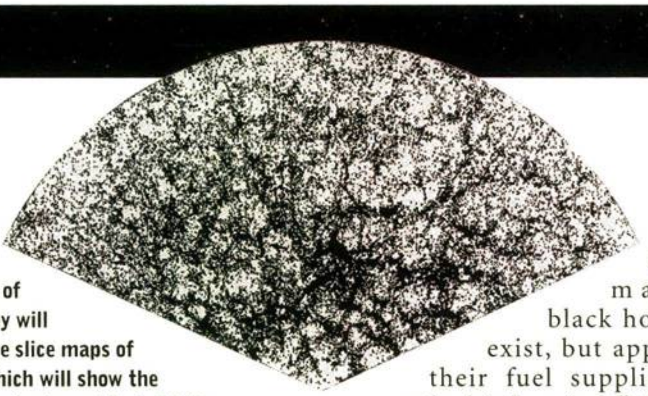


The spectrographic portion of the Sloan Survey will generate 3-D pie slice maps of the universe, which will show the distribution of galaxies out to 1.5 billion light-years. The Astrophysical Research Consortium

understand the formation and evolution of galaxies in the survey's topographical map of space and time.

The survey's study of quasars, some of the most distant objects known, will play a crucial role in this effort. Found at the cores of young galaxies, these mysterious objects look like stars, but they radiate 100 times more energy than typical galaxies. Yet this prodigious energy pours out of a region no bigger than our solar system. Astronomers believe that gases and even shredded stars are blazing away as they plummet into supermassive black holes at the centers of the quasars. But where did these monster black holes come from? Quasars were relatively common billions of years ago, but are rare now. Observations with the Hubble Space Telescope show that the supermassive black holes still exist, but apparently their fuel supplies have mostly dried up (see "A Beast in the Core," July 1998 issue).

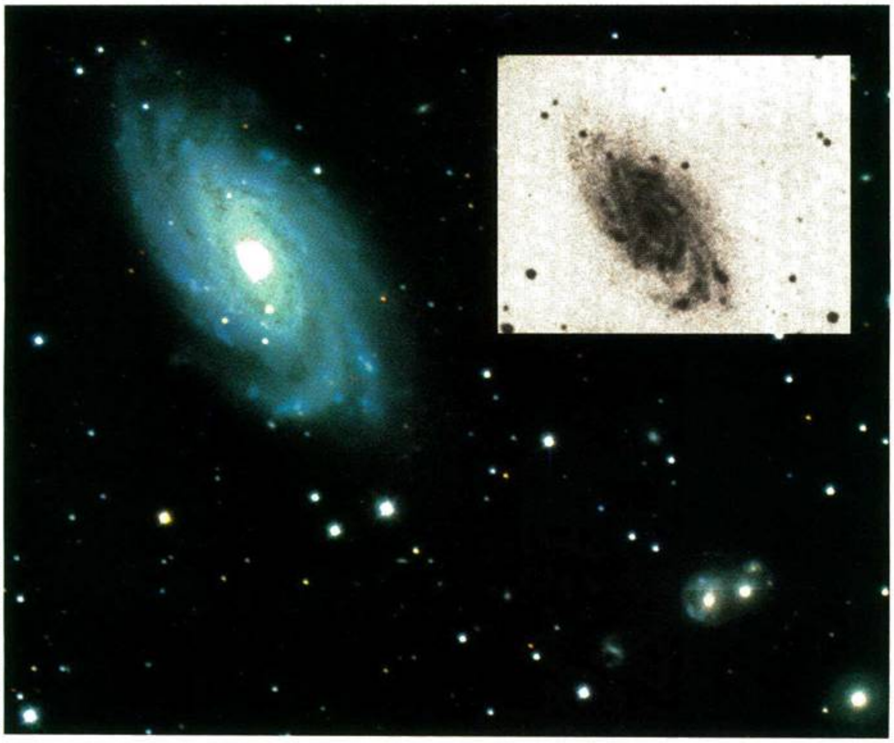
The most remote quasar discovered to date is more than 10 billion light-years away, but Sloan astronomers expect to find quasars still farther away, dating back to even earlier epochs — and to beat their own records several times over as the survey unfolds. They will be collecting reams of data on quasars: how many there are, how they are distributed, and how bright they are. The goal is to understand where quasars came from, how they evolved, and why there once were so many and now so few.

The survey's central purpose, however, is to map in unprecedented detail the largest structures in the universe, exploring the walls, voids, clusters, and superclusters of galaxies that give the universe its frothy structure. How large are superclusters? How common are they? How do their associated galaxies move with respect to one another? How much dark matter is there, and how is it distributed? The survey, combined with other surveys, will create snapshots down through cosmic time showing us how these structures formed and evolved.

That information is crucial to solving one of the deepest mysteries confronting cosmologists: How, from its beginnings with matter uniformly spread in a soup of elementary particles, did the universe emerge with galaxies concentrated in clumps like islands in an archipelago? Consider the Local Supercluster, a giant concentration of galaxy clusters spanning 50 million light-years. Gravity alone could not have pulled this supercluster together during the time the universe has existed. Instead, cosmologists believe that the patchwork of structures we see today — great dense clusters, huge walls, and long strings, interrupted by stretches of seemingly endless voids — can be traced back to irregularities in the density of mass already in place in the early universe.

Indications of those irregularities emerged in 1992 when the Cosmic Background Explorer (COBE) satellite recorded minute temperature differences, varying by a mere 30 millionths of a degree, in the radiation left over from the Big Bang. This discovery indicated that when the universe was only a thousandth of its present size, only 300,000 years after it was born, there were small variations in the density of matter presumably created moments after the Big Bang by interactions in the broth of elementary particles.

The precise link between these ripples in the Big Bang's afterglow and the configurations of galaxies in our sky is not yet clear. Using Sloan data,



The 1950s Palomar Sky Survey was cutting edge at its time, but the Sloan Survey will take deep sky surveys to a whole new realm. These comparison shots of galaxy NGC 6070 show the Palomar view (inset) and the Sloan view. The Sloan frame shows exquisite detail, yet it's just a tiny part (boxed-in area) of the strip at the top of this page. Inset: NGS/POSS

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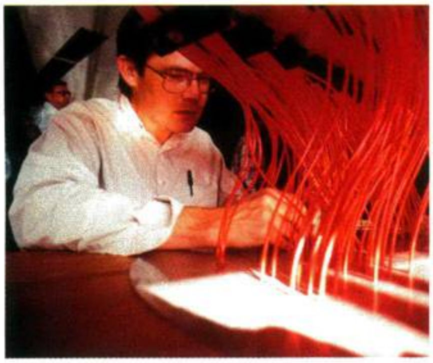


Astronomer Richard Kron, coauthor of this article, inspects optical fibers, each of which feeds the light from an individual galaxy or quasar to a spectrograph. This system can record 640 spectra simultaneously. Thomas Nash

astronomers hope to begin matching the large structures of the universe with those 10-billion- to 15-billion-year-old ripples to determine how that primordial pattern gave rise to the variegated galactic landscape we see today.

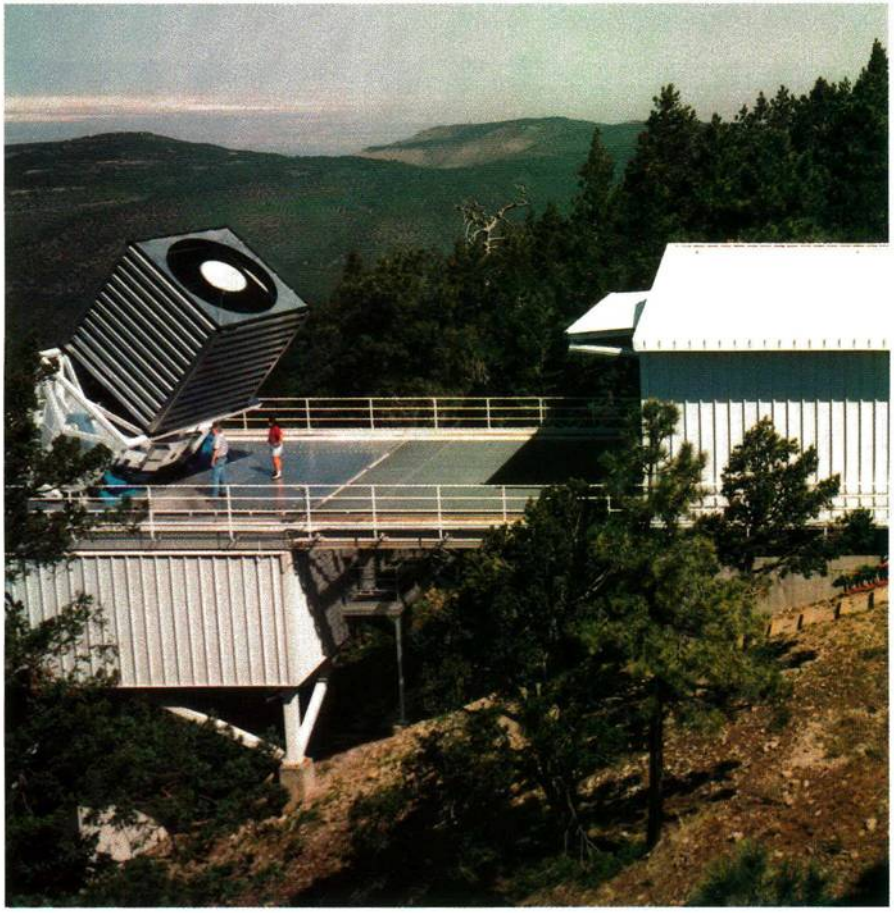
FIRST LIGHT

At the June 1998 meeting of the American Astronomical Society, scientists involved in the Sloan Digital Sky Survey unfurled a starry 30-foot banner, one of the first test images from their new telescope. A lengthy period of testing began at just about the same time. The telescope is only one of numerous complex components on the New Mexico mountaintop. There are computerized control systems that move the telescope up and down and from side to side, a 0.5-meter monitor telescope that observes standard stars so astronomers can calibrate an object's brightness, and software programs that convert pixels of data into sensible information on a star's location and brightness. Components have been tested, installed, and tested again in conjunction with other components. The imaging phase has finally begun in earnest, and spectroscopy will soon begin.

Only 70 full nights of scanning are required to photograph the survey's quadrant of the sky, and about 280 nights are required for the spectroscopic analysis. Even so, the survey is expected to take at least five years to complete because many nights will be lost due to cloud cover, atmospheric turbulence, and moonlight.

Long before the survey is completed, however, the first images are certain to stir excitement among cosmologists and astronomers, opening up the landscape of an entire continent when only a strip of shoreline was visible before. And as the first spectroscopic data roll in, a stunning three-dimensional picture of the universe will begin to emerge for scientists to explore, unimaginable without the technology available to us today. **A**

Astronomer Richard Kron works on the Sloan Survey at Fermilab and at the University of Chicago. Sharon Butler is senior editor in Fermilab's Office of Public Affairs and a freelance writer.



The Sloan Digital Sky Survey's main telescope (far left) rests atop the 9,200-foot summit of Sacramento Peak in south-central New Mexico. A storage shed sits to the right.

Fermilab Visual Media Services

PARTICIPATING INSTITUTIONS OF THE SLOAN DIGITAL SKY SURVEY

The University of Chicago
Fermi National Accelerator Laboratory
Institute for Advanced Study
Japanese Promotion Group
Johns Hopkins University
Princeton University
The United States Naval Observatory
The University of Washington

The Sloan Digital Sky Survey's website:
http://www.sdss.org/sdss.html

Ice Cream Sundaes

ILLUSTRATION BY GREG HARGREAVES

& Mashed Potatoes

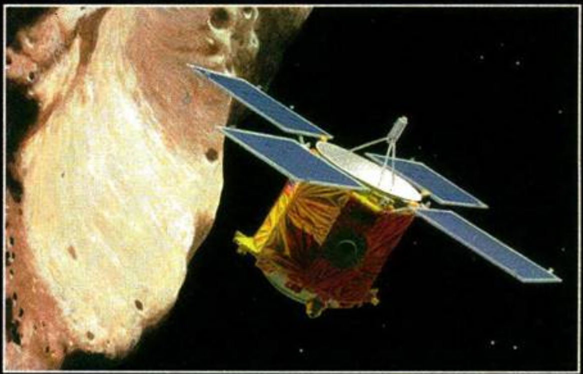
Are asteroids odd, stuck-together collections of differing fragments? NASA will soon test this idea with the first detailed look at an asteroid.

by Robert Zimmerman

Round and round the solar system it goes, and where it stops, we will all soon know. Since its launch on February 17, 1996, the Near Earth Asteroid Rendezvous (NEAR) spacecraft has whipped about the inner solar system, corkscrewing its way to its final destination.

First it took a distant journey out beyond Mars to catch a quick peek at the main asteroid belt. There it gave us our first close-up look at the large asteroid Mathilde, taking over 500 pictures. Then it swooped back in, waving impetuously at Earth as it flew by. Along the way it aimed its sensors toward deep space, listening to the powerful aftershock of several gamma-ray bursts.

The NEAR spacecraft glides above Eros. NASA/NEAR Project



Then NEAR flew outward again, this time to that nearly empty region between Earth and Mars. Now it is on its final approach to its intended mate, asteroid 433 Eros (appropriately named for the Greek god of love), where it will settle down and spend the rest of its life giving us our first intimate and detailed look at an asteroid.

Before NEAR completes its mission, scientists hope that it will help solve some of the many puzzles that surround these mysterious objects. How did asteroids form? What are they made of? And why do most meteorites appear so different from their supposed parents, the asteroids?

A Quick Look at Mathilde

The first place NEAR visited on its long, roundabout journey was the asteroid 253 Mathilde. Although discovered on November 12, 1885, by Austrian astronomer Johann Palisa, few scientists had studied Mathilde until they realized that NEAR would pass within 750 miles of its surface. By analyzing its color, brightness, and spectrum, they found that Mathilde appeared to be an irregularly shaped object with an average diameter of about 38 miles. Changes in its albedo, the proportion of incoming sunlight that it reflects, also indicated that the asteroid had an extremely slow rotation rate — 17 days and 10 hours long, the third slowest known.

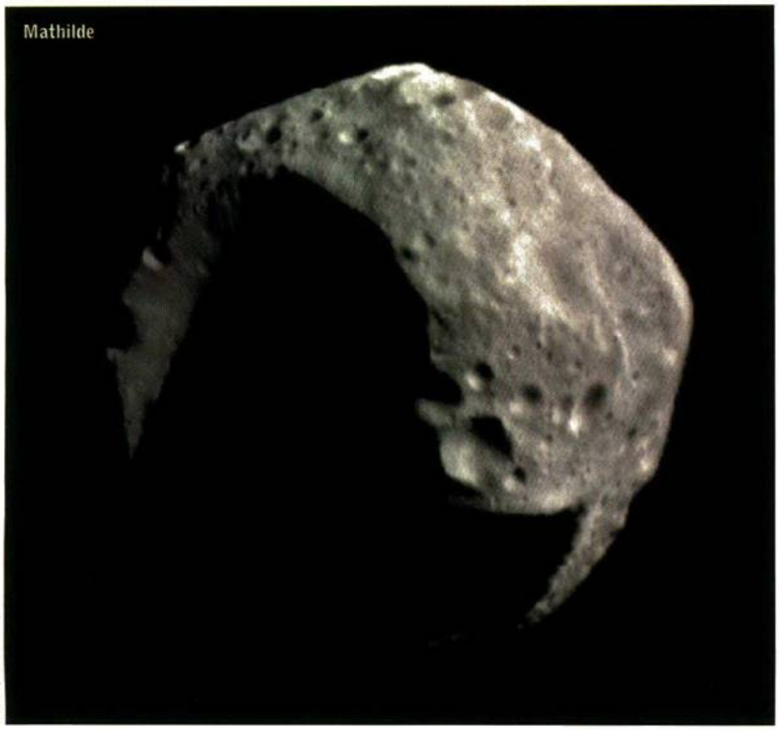
Mathilde's spectrum puts it in the C class of asteroids, where the C originally stood for "carbonaceous chondrite" because scientists saw similarities between these asteroids and the carbonaceous chondrite meteorites found on Earth. Today this classification is no longer certain. While the meteorites are made of carbon-based clays and organic compounds, the very dark C asteroids may contain iron and magnesium compounds like magnetite and ilmenite. Both the meteorites and C asteroids, however, are thought to be primitive objects, having changed little chemically since they first clumped together out of the solar system's original nebula.

On June 27, 1997, NEAR zipped by Mathilde, revealing an asteroid smaller than predicted, with an average diameter of only about 33 miles. Far more surprising, however, was the number of craters seen on this minor planet. Though scientists had expected to see a non-spherical, irregularly shaped body, nothing prepared them for the number of jagged, pockmarked features that covered its surface. "The degree to which the asteroid has been battered by collisions is astounding," said Joseph Veverka of Cornell University, lead scientist on NEAR's imaging team. "At first glance there are more huge craters than there is asteroid." The camera showed at least five craters larger than 12 miles across.

The flyby unearthed other revelations. Mathilde is almost pitch black — twice as black as a lump of coal and reflecting less than 3 percent of the light that hits it. The imaged hemisphere was also quite uniform in color. Unlike the asteroids Gaspra and Ida (photographed by the Galileo spacecraft on its looping trip to Jupiter in October 1991 and August 1993, respectively), there were no discolorations along the walls, rims, or floors of the craters, which dig down several miles. The surface and interior of Mathilde are apparently made up of the same ebony material. Nor has the asteroid's surface been noticeably altered as the solar wind blows against it.

By analyzing how Mathilde's tiny gravitational field changed NEAR's route through space,

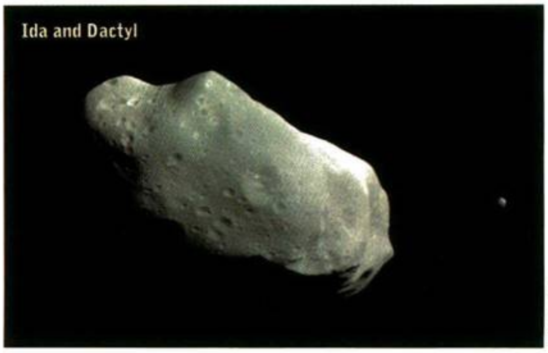
Surprises have greeted astronomers at each of the three asteroids visited by spacecraft. Gaspra, a relatively young 200 million years old, had only small craters. Ida proved the most surprising, having its own moon, Dactyl. And blacker-than-coal Mathilde featured at least five huge craters.


Mathilde

NASA/NEAR Project

Gaspra

NASA/JPL


Ida and Dactyl

NASA/JPL

Deep Space 1 Set for Asteroid Visit

by Louis Varricchio

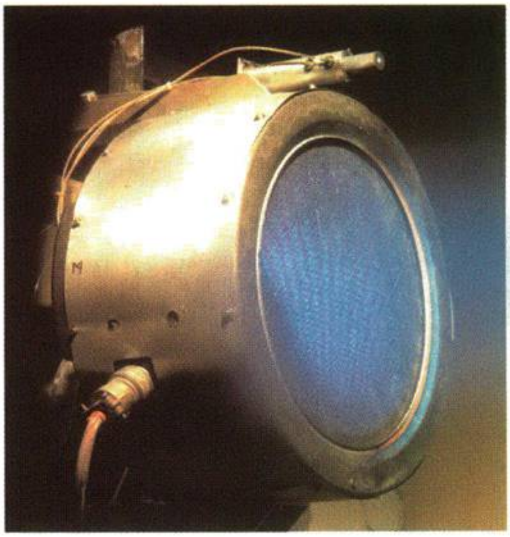
The NEAR mission isn't alone in NASA's asteroid-studying arsenal. Later this year, a spacecraft known as Deep Space 1 will fly past the asteroid 1992 KD, the first stop on a mission that could also include two comet flybys. Deep Space 1 is the flagship for NASA's New Millennium Program, which has emerged as the standard-bearer of the agency's ballyhooed "faster, better, cheaper" approach to getting planetary science missions off the drawing pad and onto the launching pad in record time and at reduced cost.

Launched from Cape Canaveral aboard a Delta II rocket on October 24, 1998, the refrigerator-sized spacecraft will demonstrate a suite of advanced space technologies that could pave the way for a Pluto flyby mission, visits to distant comets and asteroids, and a possible return mission to Mercury early in the 21st century.

At a cost of $152 million, approximately one-half the cost of the Mars Pathfinder mission, Deep Space 1 will test 12 new technologies. Perhaps the most intriguing of these is an ion-propulsion system. The futuristic system works by creating scads of ionized xenon atoms which have each lost one electron in collisions with a beam of electrons. The ions then pass through an electric field that accelerates them to more than 60,000 miles per hour and shoots them out the back of the spacecraft.

Although each individual ion creates a minuscule thrust, the combined kick from 180 pounds of xenon fuel working for 20 months is enough to send the spacecraft on its way. According to Marc Rayman, Deep Space 1's Deputy Mission Manager and Chief Mission Engineer, "Ion propulsion reduces the weight and cost of carrying chemical propellants." Indeed, the same amount of chemical propellants would impart only one-tenth the acceleration that Deep Space 1 will get from its ion-propulsion engine.

Among the other technologies to be tested by Deep Space 1 are a solar-power system that uses cylindrical lenses to concentrate sunlight onto an array of 3,600 solar cells; a smart, autonomous navigation system; a new imager with non-moving parts; a space-capable low-power electronics package; a communications system which will reduce reliance on the Deep Space Network; and an ion and electron spectrometer for measuring the effects of the solar wind.



NASA

The ion engine onboard Deep Space 1 gets a workout on Earth before launch. The engine is just one of a dozen new technologies being tested on the mission.

The mission, organized jointly by the Jet Propulsion Laboratory and Spectrum Astro Inc., isn't all nuts and bolts. Deep Space 1 will have some planetary science to conduct. On July 28, 1999, it will fly past and analyze 1992 KD, a 2-mile-long asteroid discovered in 1992 by Eleanor Helin and Ken Lawrence. The asteroid belongs to the Amor group of minor planets, meaning that its perihelion, the closest point in its orbit to the sun, falls between the orbits of Earth and Mars. The close-up look provided by Deep Space 1 will be the first of an Amor asteroid.

Although the primary mission is planned to last until September 18, 1999, if the flight is successful it may be extended to the year 2000. Then Deep Space 1 will attempt flybys of Comet Wilson-Harrington (thought to be a burned-out comet) and Comet Borrelly, one of the most active of the short-period comets.

However, JPL planners stress that visiting an asteroid or a comet is not considered a requirement for Deep Space 1. In this mission for the future, what counts is the success of the technology.

Louis Varricchio is a freelance science correspondent heard on Public Radio International and a graduate student in Space Studies at the University of North Dakota. He lives in Middlebury, Vermont.

astronomers estimated the asteroid's mass to be about 110 trillion tons. Combined with the asteroid's volume, this yields a density of about 1.1 to 1.5 grams per cubic centimeter — only slightly denser than ice. Since most chondritic material has a density twice this, Mathilde must either be very porous, with many internal cavities and spaces, or something resembling a gravel pile of primordial material only loosely stuck together.

The most astonishing discovery, however, was how the older craters seemed undamaged by subsequent impacts. The expectation, based on Galileo photos of Gaspra and Ida and Viking photos of the asteroid-like martian moons Phobos and Deimos, was that on such a small surface, large impacts would shatter the surrounding terrain, causing cracks, fractures, and grooves. These in turn would act to erase earlier craters.

This doesn't seem to be the case with Mathilde. Collisions have gouged deep craters in its surface, but nearby older craters have hardly been affected. Somehow, the shock of the impacts is so localized that the loosely packed material can't shake apart adjacent geological features.

It's as if Mathilde is not unlike a soft crunchy glob of partly mashed potatoes. It can hold its shape forever, is easily molded when touched, but only changes in the places you poke it.

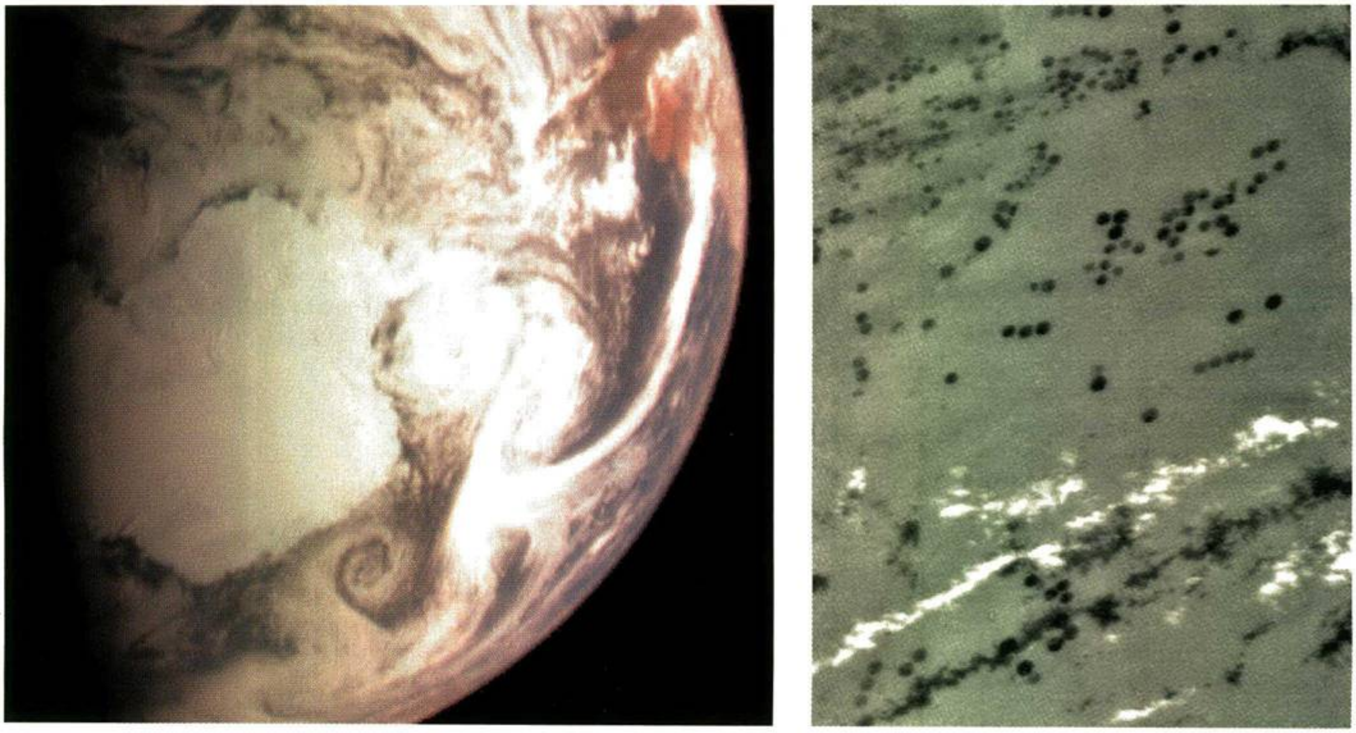
On to Eros

NEAR's flyby of Mathilde was only the beginning. Seven months later, on January 23, 1998, the probe flew past Earth for a gravity assist needed to reach Eros. Speeding within 335 miles of our planet at about 20,000 miles per hour, NEAR became the first interplanetary manmade object visible to the naked eye from the United States. As the spacecraft whisked by, scientists calibrated its equipment by aiming its instruments homeward.

NEAR's flyby of Earth modified its orbit as planned. The probe is now nearing its final destination, the asteroid 433 Eros. In January 1999, it began a series of four main thruster burns to ease its way into orbit (if orbit is the right word for such a delicate dance between the asteroid's tiny gravitational field and the spacecraft's thruster engines). These burns will leave NEAR with a breathtakingly slow speed of only 11 miles per hour relative to Eros. During this time, NEAR's camera will search for any moons circling Eros, both for the scientific bonanza such a finding would entail and to help avoid any possible collision with the spacecraft. Although the initial orbit will stretch out to some 620 miles from Mathilde, by the end of February the probe will have settled into a circular orbit about 120 miles high. During the next few months, NEAR will slowly work its way in, slipping into a weaving variety of orbits ranging from about 15 to 60 miles above the asteroid's surface.

If all goes right, in early February 2000, NEAR will then inch its way downward, getting as close as possible to Eros's surface and perhaps even landing. "If we can get NEAR to touch down and even bounce off without damage we could find out whether the surface is hard or soft," says project scientist Andy Cheng of the Applied Physics Laboratory of John Hopkins University.

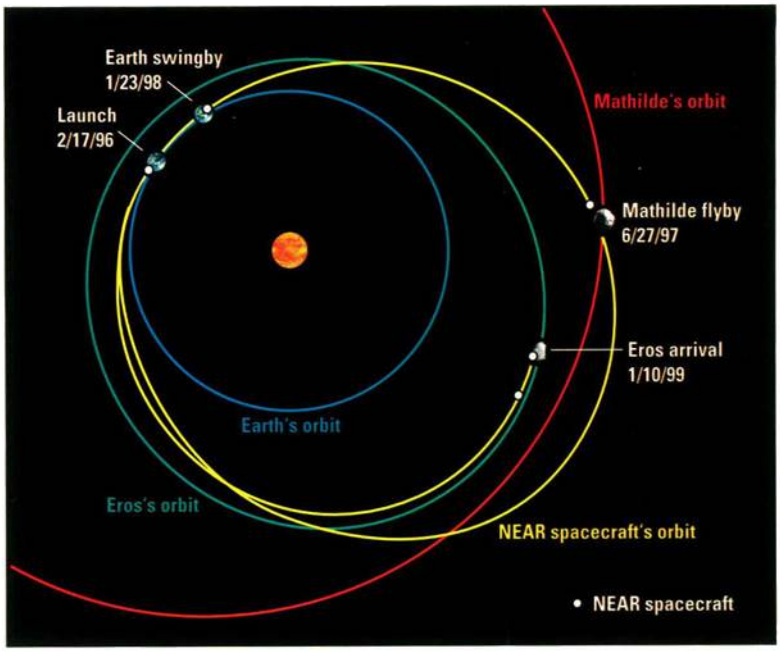
All along the way NEAR will be photographing Eros from every angle. The spacecraft will also use two spectrometers to identify the asteroid's mineralogical make-up, a laser altimeter to measure its surface contours to an accuracy of 20 feet, and a magnetometer to detect any magnetic fields.



Antarctica appeared at center and South America at the upper right in this NEAR view of Earth (left). The image was taken in January 1998 from about 100,000 miles. From 430 miles high, Saudi Arabia shows irrigated fields and a possible jet contrail (right).

NASA/NEAR Project

NASA/NEAR Project



Astronomy: Elisabeth Rowan

NEAR's roundabout journey to Eros included a close flyby of the asteroid Mathilde in June 1997 and a gravity assist from Earth in January 1998.

Eros is in many ways completely different from Mathilde. For example, Eros belongs to the S class of asteroids, where the S originally stood for "silicate." S types form the bulk of both the inner part of the asteroid belt and most Earth-approaching asteroids. Though their mineralogy is not known precisely, they are sometimes called stony-irons because spectra indicate the presence of iron and magnesium silicates (minerals dubbed either pyroxene or olivine), with some nickel and iron alloys thrown in. What is known is that unlike the primitive C-type asteroids, S types have undergone some heating or melting since they formed.

Also unlike Mathilde, Eros has been studied extensively through the years, partly because of its proximity to Earth. Recently scientists at the Jet Propulsion Laboratory in California did some radar scans and found that Eros is probably shaped like a very elongated kidney bean, about 21.5 miles long and 10 miles across, and rotates every 5 hours and 16 minutes. Its convex side, rich in pyroxene, seems to be splattered with many small concavities. The astronomers do not know if these are craters, grooves, or cracks. On the kidney bean's concave side, the radar study found a much smoother surface, and the dominant mineral was olivine, not pyroxene.

While Eros might very well be a rubble pile like Mathilde, it does not appear to be the same throughout. The olivine and pyroxene hemispheres indicate at least two different and mineralogically distinct sections.

Scientists postulate two explanations for Eros's shape and substance. On one hand they imagine Eros to be a collection of many different fragments of many different sizes that are gently stuck together. Imagine an ice cream sundae without the hot fudge. Clumps of ice cream, banana, nuts, sprinkles, and whipped cream all cling together as they race through space. Though Eros's material is probably denser than whipped cream and ice cream, its structure might not be much more stable than this hypothetical sundae. The asteroid would have formed when, over time, these different chunks of material would have slowly congregated in space, pulled together by their minuscule gravitational fields.

On the other hand, Eros might simply be a single fragment blown free when a larger object was shattered apart in a collision eons ago. The disparity between Eros's two hemispheres would then exist because the asteroid's parent body, larger and more dense, would have begun to differentiate into layers. Like Earth it would have had a heavier core with a lighter mantle. When Eros was cracked off, one side was dominated by olivine while the other side had more pyroxene.

The Connection with Meteorites

Scientists hope NEAR's close look at Mathilde and Eros will solve one of the biggest mysteries of asteroid and meteorite study: To what asteroid class do meteorites belong? Scientists think that nearly all meteorites were once parts of asteroids, and collisions broke off pieces and changed their orbits to ones intercepting Earth.

Although the S and C classifications make up almost 75 percent of all known asteroids, the spectrum of neither type corresponds very closely to most meteorites found on Earth. In fact, only a handful of asteroids fit precisely the spectral class of 90 percent of all known meteorites.

Even more puzzling, the closer you get to Earth, the worse the match. C asteroids, orbiting from the middle of the asteroid belt outward, match only poorly. S asteroids, orbiting from the middle of the asteroid belt inward, match not at all. While almost all near-Earth asteroids belong to the S class, only 10 percent of meteorites found on Earth resemble these asteroids even vaguely.

In many ways the study of asteroids today is comparable to the study of the major planets in 1968. Before the first orbital missions to Mars and Venus, most of our knowledge of the planets was based on their telescopic appearance and spectra. Our only good views had been limited to a few quick flybys, mere glimpses by a handful of spacecraft. Overall we knew little and understood less.

Similarly, other than the tantalizing glimpses provided by the NEAR and Galileo spacecraft, we have not yet seen an asteroid in detail. Astronomers have approximated the make-up and shape of these mysterious objects, but without actually *looking* at them close up, we can't really *know* what they are. This should all change in 1999, as NEAR slips into orbit around Eros and begins to pick at its mysteries.

Robert Zimmerman writes frequently for Astronomy *and other science and space publications. His book,* Genesis: The Flight of Apollo 8, *was published last fall by Four Walls Eight Windows and is available in bookstores.*

Mastering

the Universe

Edwin Hubble gained scientific immortality when he discovered an expanding universe of galaxies.

by Gale Christianson

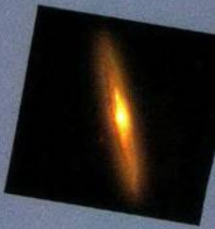
AFTER PEERING IN WONDER, NIGHT after night, through his homemade telescope, Galileo Galilei believed that he had at last solved the riddle of the Milky Way, which to him was the universe entire. "The galaxy is, in fact, nothing but a congeries of innumerable stars grouped together in clusters," he wrote in his little classic, *The Starry Messenger*. "Some are rather large and quite bright, while the number of smaller ones is quite beyond calculation." Although the dimensions of the galaxy would be vastly expanded by astronomers over the centuries, many still believed that the Milky Way and the universe were one and the same when Edwin Powell Hubble set foot for the first time on California's Mount Wilson in September 1919.

Hubble, who was still wearing the major's uniform he loved, had just received his discharge from the army. Much to his chagrin, he had arrived in France only days before the November armistice was signed, quieting the guns on the Western Front and ending his dreams of leading men into battle. If he was to make a reputation for himself, he would have to do it with a giant celestial cannon aimed at the jugular of the universe.

Edwin Hubble at the 48-inch telescope on Palomar Mountain. Historic Photo: The Observatories of the Carnegie Institution of Washington. Inset photo: Bill and Sally Fletcher

And do it he did, uncovering the nature of our expanding universe and coming up with a method for classifying the multitude of other galaxies to be found in it. Hubble's revelations were so enormous and well publicized in the 1930s that he became a popular celebrity and brought the stars of Hollywood to his feet.

At six-foot-two and 190 pounds, the handsome astronomer was an imposing presence. Assistant astronomer Milton Humason described him as a "tall, vigorous figure, pipe in mouth," his military trench coat wrapped tightly around his lithe frame. Hubble was further set apart by the English accent he had picked up during his Rhodes Scholar days at Oxford University, not to mention the knickers, jodhpurs, high-topped military boots, and Norfolk jacket that were a regular part of his observatory wardrobe.



It did not take long for Hubble to settle in at Mt. Wilson. Christmas Eve 1919 found him alone on top of the world detached from this small planet circling its little star, his fingers and thumbs poised on the buttons of the giant 100-inch Hooker Telescope, the greatest gift any observer could desire.

When the Milky Way was the Universe

Among Hubble's colleagues on the mountain was the irrepressible Harlow Shapley, a pioneer in estimating the dimensions of the

All galaxy photos: Zsolt Frei, Princeton University

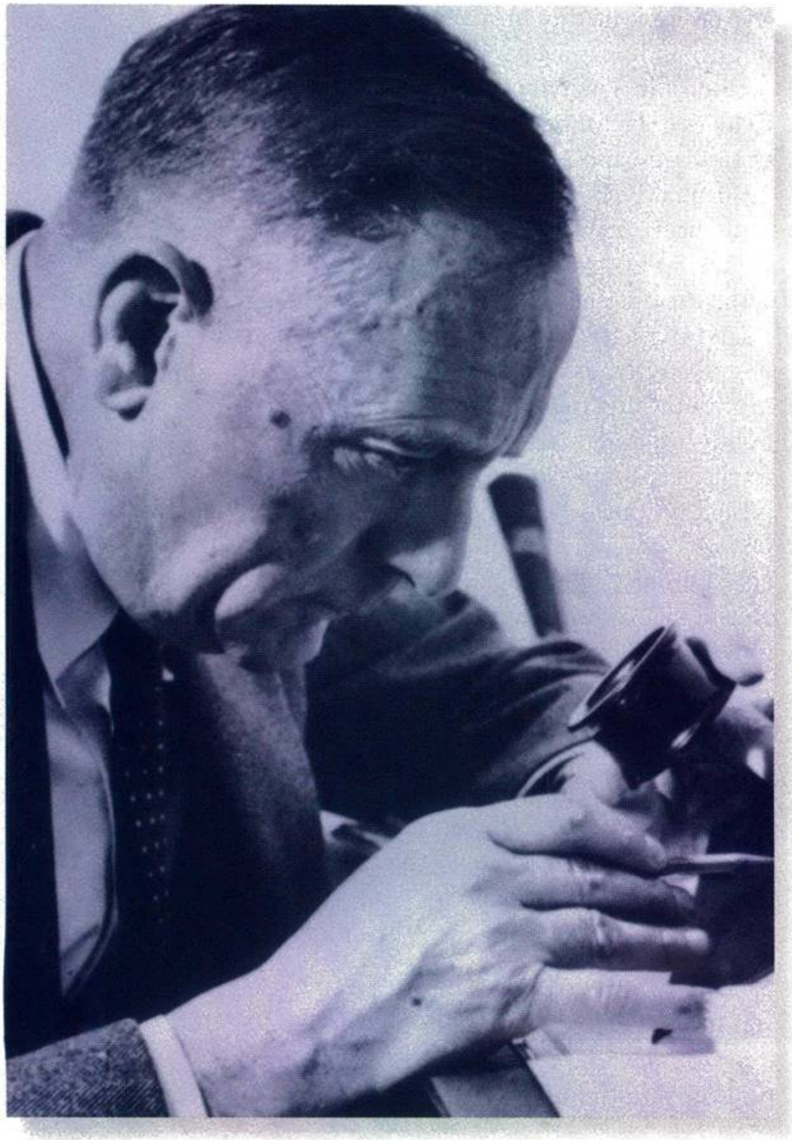
Milky Way by photographing variable stars in globular clusters. Like Galileo, Shapley believed that the Milky Way was the universe, but a much larger one than the Italian had dared dream. Three hundred thousand light-years across was Shapley's jarring estimate — the "Big Galaxy," as he dubbed it — ten times larger than anyone had previously envisioned.

Among Shapley's most outspoken critics was the astronomer Heber Curtis of California's Lick Observatory, located atop Mount Hamilton, near San Jose. Curtis argued that not only had Shapley grossly inflated the size of the Milky Way, in doing so he had committed an even greater blunder. Curtis firmly believed that our galaxy was only one of many whose numbers are beyond counting, that the ethereal wisps, or nebulae, captured by astronomers as faint images on glass plates were really independent galaxies strewn across space like a cosmic archipelago.

Here matters stood until the night of October 5, 1923, when fate took Edwin Hubble by the hand. With the 100-inch locked on a spiral arm of the Andromeda Nebula (known to astronomers as M31), he took a 45-minute exposure, labeling the plate H335H, the initials standing for "Hubble" and "Hooker Telescope" and the number representing the 335th photograph taken by the astronomer on the 100-inch. When he developed it later in the day, Hubble believed that it contained images of three previously undiscovered novae, variable stars that increase in brightness to several times their normal magnitude before dimming to their original appearance.

Grace Burke Hubble in 1931. She waited with the cat in their Spanish-style bungalow in San Marino when Edwin was up the mountain at the telescope.

Huntington Library, San Marino, California


Edwin Hubble at his desk studying images in 1948.

The Observatories of the Carnegie Institution of Washington.

His run completed, Hubble returned to his office in Pasadena the next day, where he undertook a more thorough examination of the plates. He quickly discovered that one of the novae was not a nova at all, but a Cepheid variable star, a particular type whose well-known period-luminosity relationship described its absolute brightness. After plotting the object's light curve, he employed distance-measuring techniques and was rocked when he discovered the Cepheid to be at least 300,000 parsecs from Earth — the equivalent of a million light-years, or more than triple the diameter of Shapley's entire universe. Staggering though it seemed, what Galileo had written about the stars Hubble could now claim for the galaxies themselves — "congeries innumerable."

Tuning Forks

Another knotty, if less glamorous, problem faced by astronomers was how to classify the galaxies in hopes of arriving at an understanding concerning their formation and evolution. Having studied and rejected various schemes developed by others, Hubble came up with his own in the early 1920s — the now classic cosmic "tuning fork" diagram. The handle of the fork is composed of elliptical nebulae, subdivided according to how flattened they appear. Those that are perfectly circular he called E0 nebulae: several steps removed are the E7 ellipticals, the flattest of their kind, reminiscent of a slightly elongated football.

The tines of the fork are composed of elegant spirals, which resemble pinwheels. These Hubble divided into normal spirals and a smaller but distinctive subgroup called barred spirals, so named because their curved arms originate from the end of a "bar" running through their nuclei rather than from the nuclei themselves. Just as the ellipticals are classified according to their degree of flatness, the spirals — both normal and barred — are divided into subclasses based on the tightness of their arms. An Sa designation denotes a normal spiral with tightly wound arms; SBa is the symbol for its counterpart within the barred category. Sc and SBc spirals are the most loosely wound of all.

Still, perfection was elusive. Some few of the nebulae, such as the Small and Large Magellanic Clouds, lacked what Hubble termed "rotational symmetry." They appeared to be warped, twisted, or stretched, perhaps as the result of primordial explosions or close encounters with trespassing neighbors. Thus the astronomer had no choice but to add a catchall designation, the so-called irregular nebulae.

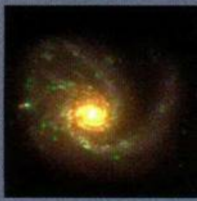
Although astronomers remain puzzled by the evolution of the spiral arms issuing from the galaxies like flagella, Hubble's classification scheme has endured. The great astronomer Walter Baade, Hubble's colleague at Mount Wilson for more than two decades, summed it up beautifully in a lecture at Harvard: "I have used [the classification scheme] for 30 years, and although I have searched obstinately for systems that do not fit it, the number of such systems that I finally found is so small that I can count it on the fingers of my hand."

Nicolas Copernicus, the Hubbles' Cat

Hubble's wife, Grace, needed no calendar to tell her when her husband was about to embark on a run. He fiddled absentmindedly with his bacon and eggs, a distant look in his eyes, and showed none of his usual interest in the newspaper or conversation. Truth to tell, he was already gone. After he stuffed his clothing, a few books, a tin of tobacco, and a flashlight into his battered military suitcase, Grace drove him to the observatory offices on Pasadena's Santa Barbara Street, where a truck was already waiting to carry him up the mountain. "Take care of yourself," were his parting words as he jumped out and hurried away with a look of "absorbed enthusiasm." Feeling very much alone, Grace returned to their comfortable Spanish-style house in San Marino to wait out the days and nights in the company of Nicolas Copernicus, the Hubbles' cat.

Edwin Hubble was captured for the first time with a telescope in this 1914 photograph taken at the Hale house in New Albany, Indiana. Huntington Library, San Marino, California

When Edwin wasn't on a run, the mood was different. His work on the mountain had brought him to the attention of various members of the Hollywood community, and friendships blossomed. Among those close to the Hubbles were the actress Helen Hayes and her irreverently flamboyant husband, the playwright Charles MacArthur. Aldous Huxley, author of *Brave New World*, had come to California to write for the movies and visited Hubble during a run. Huxley demonstrated his grasp of Einsteinian physics when, on peering through the 100-inch, he joked that he half-expected to see his own backside. It was the beginning of a fast friendship that lasted until Hubble's death in 1953, when Huxley wrote a devastated Grace, "Love remains — for it is what 'moves



Grace and Edwin Hubble made life an adventure in southern California.

Huntington Library, San Marino, California

the sun and the other stars,' which is something that Edwin knew even better than Dante."

On the night of March 4, 1937, the Hubbles attended the annual Motion Picture Academy Awards ceremonies at the Biltmore Bowl in Los Angeles. They were guests of the director Frank Capra, who had already won one Oscar and was on the verge of receiving another. Capra was also president of the Academy and saw to it that the Hubbles were seated at his table. He began the proceedings by introducing the world's greatest living astronomer and asking Hubble to stand. As he did so, three spotlights converged on him, while the auditorium resounded with applause. "Next to invoking the Deity," a star-struck Grace gushed, "this seemed for some mysterious reason the correct way to begin."

Winning Notoriety

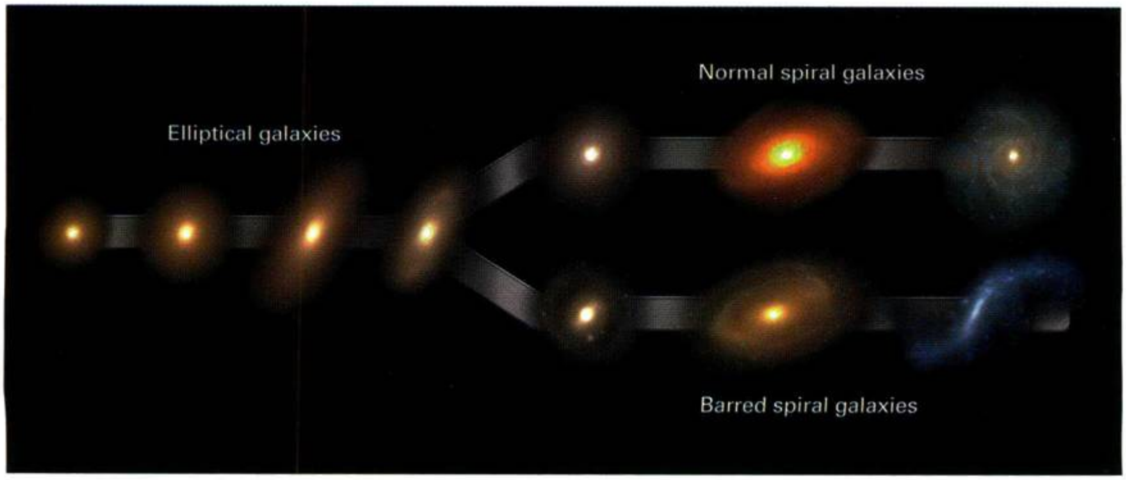
The discovery that elevated Hubble to the status of a celebrity unfolded during the late 1920s and early 1930s. Ever since the 19th century, scientists had known that light, like sound, behaves in many ways as if it were a wave; the motion of the source affects the wavelength of the light. Thus, if a light source is moving toward a viewer the spectral lines are shifted toward the blue, or blueshifted; if the light source is moving away from the observer the spectral lines are shifted toward the red, or redshifted. The amount the lines shift — the so-called Doppler shift — reveals the radial velocity of the light source.

In 1912 Vesto Melvin Slipher, an astronomer at Flagstaff's Lowell Observatory, had mounted a slitted spectrograph on the 24-inch Lowell refractor and photographed more than 40 nebulae. The results were nothing less than astounding. With one or two exceptions, the nebulae were all redshifted, hurtling away from the sun at speeds as high as 1,100 kilometers per second. Everything hinged on obtaining credible estimates of the distances of the nebulae, and then establishing a correlation with the velocities of their recession. To accomplish this, however, a much larger telescope was needed.

Some 16 years later, Hubble invited Milton Humason to his office. A former janitor and night assistant with a grammar school education, Humason had been promoted to assistant astronomer in 1922, largely for his exceptional ability to photograph distant objects. As Humason remembered it, Hubble thought that the fainter the nebulae the greater their distance from Earth — and the larger the redshifts: "[he] asked me if I would check that out."

If, as Hubble conjectured, a nebula's velocity of recession was truly an index to its distance, then the distances of nebulae far across the universe could be inferred by simply measuring their redshifts. Humason set to work readying the telescope, and in weeks the unlikely pair hoisted sail, setting a course for far-flung waters, Humason in the crow's nest and Hubble at the helm.

For his first plate Humason intentionally picked a nebula whose redshift Slipher had not been able to obtain because of its distance from Earth. Photographing through a yellow prism that blocked the ultraviolet light, the assistant



Edwin Hubble developed a classification system for galactic structure based on the design of a tuning fork. The handle holds *elliptical* galaxies subdivided by the roundness of their shape. Elegant spiral galaxies and barred spirals compose the tines of the fork.

Astronomy: Elisabeth Rowan

astronomer captured a faint spectrum he later described as "poor." Still, the so-called H and K lines produced by calcium atoms in the nebula were definitely shifted to the right or red end, as Hubble had expected.

Confirming the Shifting Galaxies

Humason immediately telephoned the elated astronomer, who was waiting for him at Santa Barbara Street when he completed his historic run. Hubble confirmed the redshift, calculating it at some 3,000 kilometers per second, about 1,800 kilometers per second greater than Slipher's highest value. When he was queried about his feelings at the moment of triumph years afterward, the educationally deprived Humason claimed the poet Byron as his model, though he could offer no reason why.

Humason was soon gathering spectra on the great spirals like M33, M51, and M101, the heart of Messier's catalog compiled a century and a half earlier. The redshifts were confirmed: in all directions, the nebulae appeared to be hurtling away from Earth, or Earth from them. Based on his calibration work with Cepheids, Hubble quickly established the first linear relation between the degree of spectral displacement and the estimated distance to the observed object — the greater the redshift, the more remote the source of light.

The published results represented a giant step in modern cosmology. In place of a static picture of the cosmos, the universe had to be regarded as expanding, the very cornerstone of what would become known as the grand creation event, first termed the "big bang theory" by the astronomer Fred Hoyle in 1950.

Having more than quadrupled Slipher's largest displacement, Humason added new velocities at the rate of ten a month, forging beyond Virgo to Pegasus, Pisces, Cancer, Perseus, Coma, and Leo, whose speed of recession was calculated at a dizzying 19,700 kilometers per second, a figure that Humason would more than double before he finally ran out of telescope.

Scientific Immortality

As he always did, Hubble would come striding down the hall when Humason returned from the mountain to ask what luck he had had. When Humason handed him the new exposures of spectra he would pick up a pencil and pad and jot down the figures as fast as the pencil could move, calculating the distances within minutes. Gradually, the now famous principle destined to bear his name took shape. According to Hubble's Law, the distances and recessional speeds of the nebulae are in direct proportion to each other. Double the distance to a galaxy and the speed doubles; triple the distance and the speed triples. A galaxy at a distance of 100 million light-years is moving away from Earth twice as fast as a galaxy that is 50 million light-years away from us.

Writer Aldous Huxley and Edwin Hubble enjoyed a lasting friendship. Huxley's screenwriting career made him a rich man and his purchase of a new Cadillac impressed the Hubbles, who went and bought one for themselves. Huntington Library, San Marino, California

Having garnered scientific immortality, Hubble was sought out by none other than the living god of science himself. In January 1931, Albert Einstein arrived in Pasadena for a fateful meeting with Hubble. During the metaphorical laying on of hands, the physicist explained how he had "judged" his equations to make them conform to the astronomers' insistence that the cosmos was static. Einstein called it the greatest aesthetic blunder of his life, and publicly thanked Hubble for restoring his faith in universal motion.

When Edwin wasn't available, Grace Hubble drove Einstein to his meetings and appointments. He was silent sometimes, and sometimes he would talk in French or English, for Grace knew no German. One afternoon he broke his silence to say, "Your husband's work is beautiful."

Gale E. Christianson, a Guggenheim fellow and historian at Indiana State University, is the author of Edwin Hubble: Mariner of the Nebulae, *as well as biographies of Isaac Newton and Loren Eiseley.*

The Universe.

Milky Way photo courtesy of NOAO.

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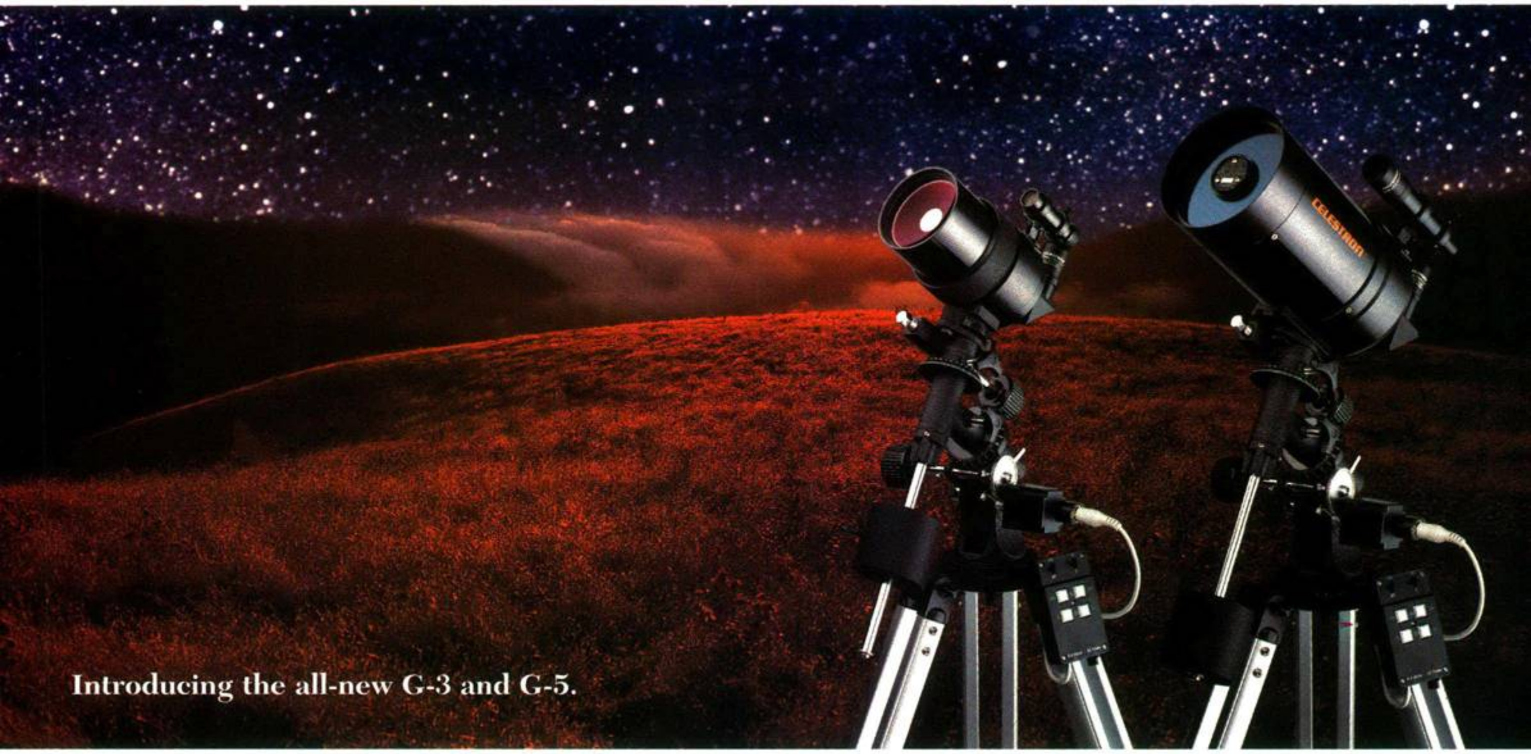

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THE SKY SHOW

February's cold, crisp evenings are highlighted by a meeting of the celestial gods. by Martin Ratcliffe and Alister Ling

▶ The best conjunction of the year, perhaps the best for more than a decade, occurs this month. Two brilliant planets, **Venus** and **Jupiter**, dress up the evening sky and pass within 0.1° of each other in the final week of February. The addition of a thin crescent moon a few days before the conjunction makes this a highly photogenic evening sky. Not since 1990 have these two planets paired up so closely, and that was an early morning event.

Venus plays its role as the evening star admirably. The bright magnitude –4.0 planet continues its climb away from the sun. On February 1, it lies 22° to the east of the sun and sets two hours later. Jupiter, at magnitude –2.1, lies roughly 22° farther east along the ecliptic in Pisces. As each day passes, Venus edges one degree closer to Jupiter. By the new moon on February 16, the two planets lie only 7° apart. At about the same time, tiny **Mercury** joins the evening activity. Mercury sets 45 minutes after the sun and attempts to shine through the bright twilight on February 16. Mercury's visibility improves as it approaches greatest eastern elongation early in March.

The slender crescent moon lies 5° southwest of Venus on February 17. One night later the thickening crescent lies 4° east of Jupiter. These are the final days before the conjunction. On the evening of February 22, Venus lies a mere 0.8° west of Jupiter. Both planets are visible through a telescope in the same low-power field of view. Though Jupiter is farther away, the 89-percent-illuminated disk of Venus appears one-third the size of Jupiter's 33" diameter. Venus lies 133 million miles from Earth and Jupiter is a staggering 540 million miles away. The two planets are separated by 400 million miles.

The two planets get as close as 0.1° on February 23.

George Livadras

Venus and Jupiter rise over the Riviere des Prairies in Montreal, Canada. Look for Venus, Jupiter, and Saturn to grace our evening skies this month.

FEBRUARY 1999

1 The moon passes 0.3° north of Regulus, 7 P.M. EST
Uranus is in conjunction with the sun, 8 P.M. EST

3 Mercury is in superior conjunction, 11 P.M. EST

4 Asteroid Vesta is at opposition, 2 A.M. EST

6 The moon passes 3° north of Mars, 10 P.M. EST

8 The moon is at apogee (251,274 miles from Earth), 2:52 A.M. EST
Last quarter moon is at 5:58 A.M. EST

14 The moon passes 1.5° north of Neptune, 6 A.M. EST

15 Asteroid Hygiea is at opposition, 6 P.M. EST

16 New moon is at 12:39 A.M. EST; annular solar eclipse

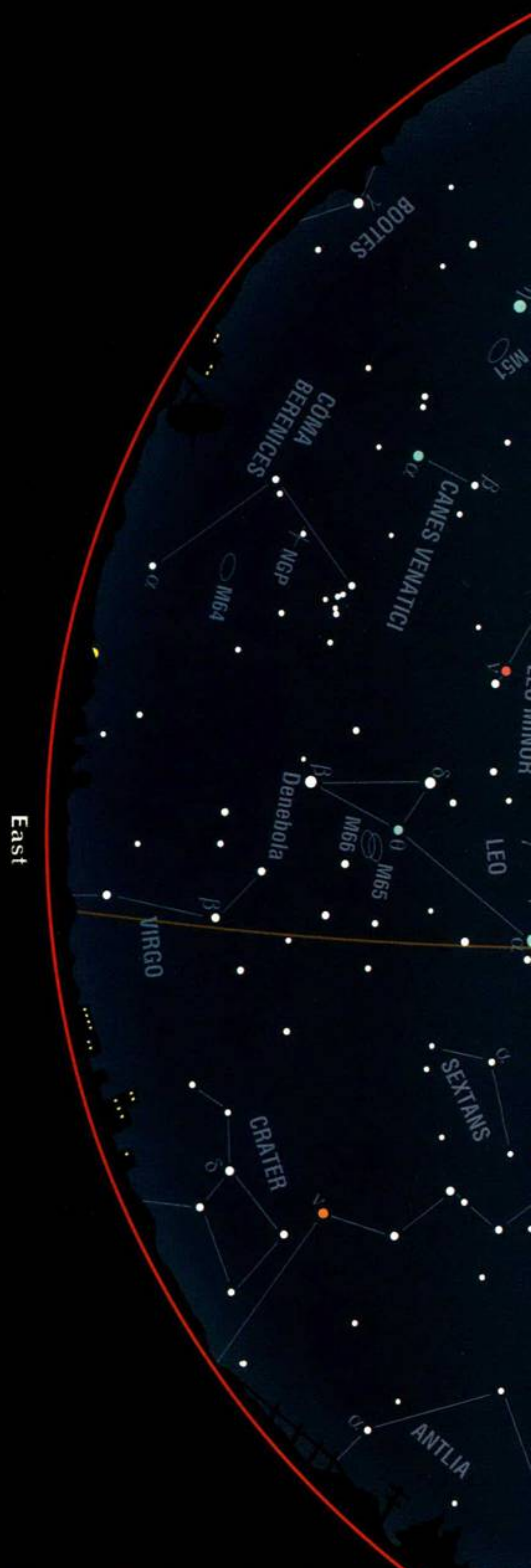
17 The moon passes 1.8° south of Venus, midnight EST

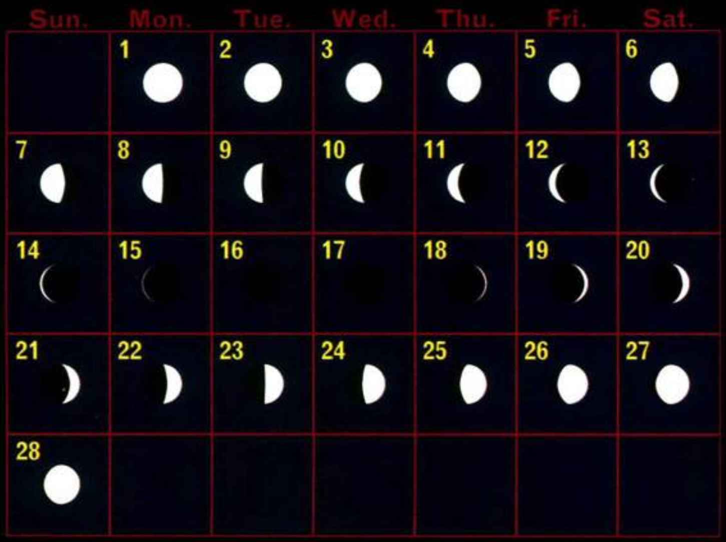
18 The moon passes 2° south of Jupiter, 10 A.M. EST

20 The moon is at perigee (229,071 miles from Earth), 8:34 A.M. EST
The moon passes 3° south of Saturn, 9 A.M. EST

22 First quarter moon is at 8:43 P.M. EST

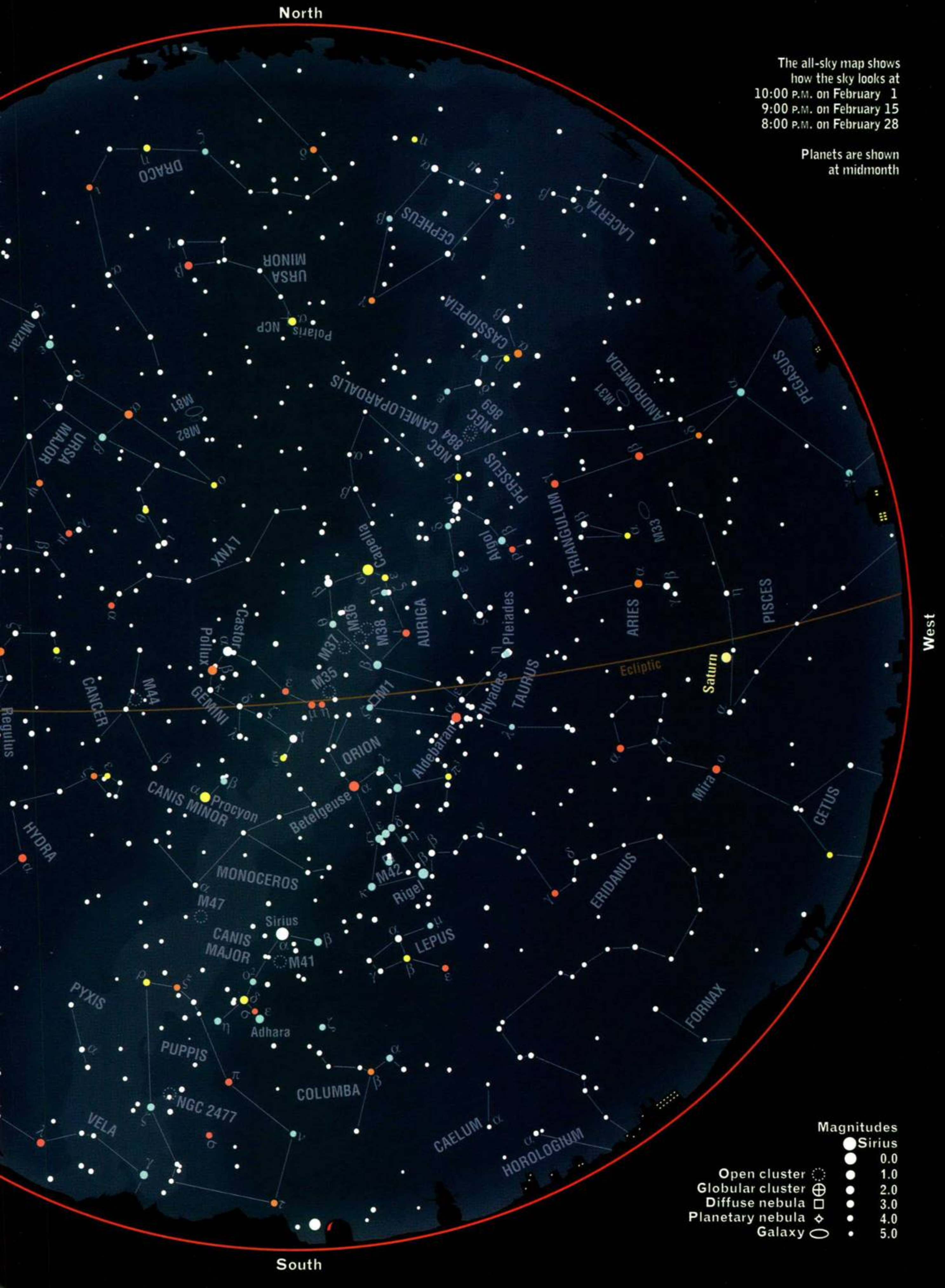
23 The moon passes 0.4° north of Aldebaran, 7 A.M. EST
Venus passes 0.1° north of Jupiter, 3 P.M. EST (page 76)





Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28						

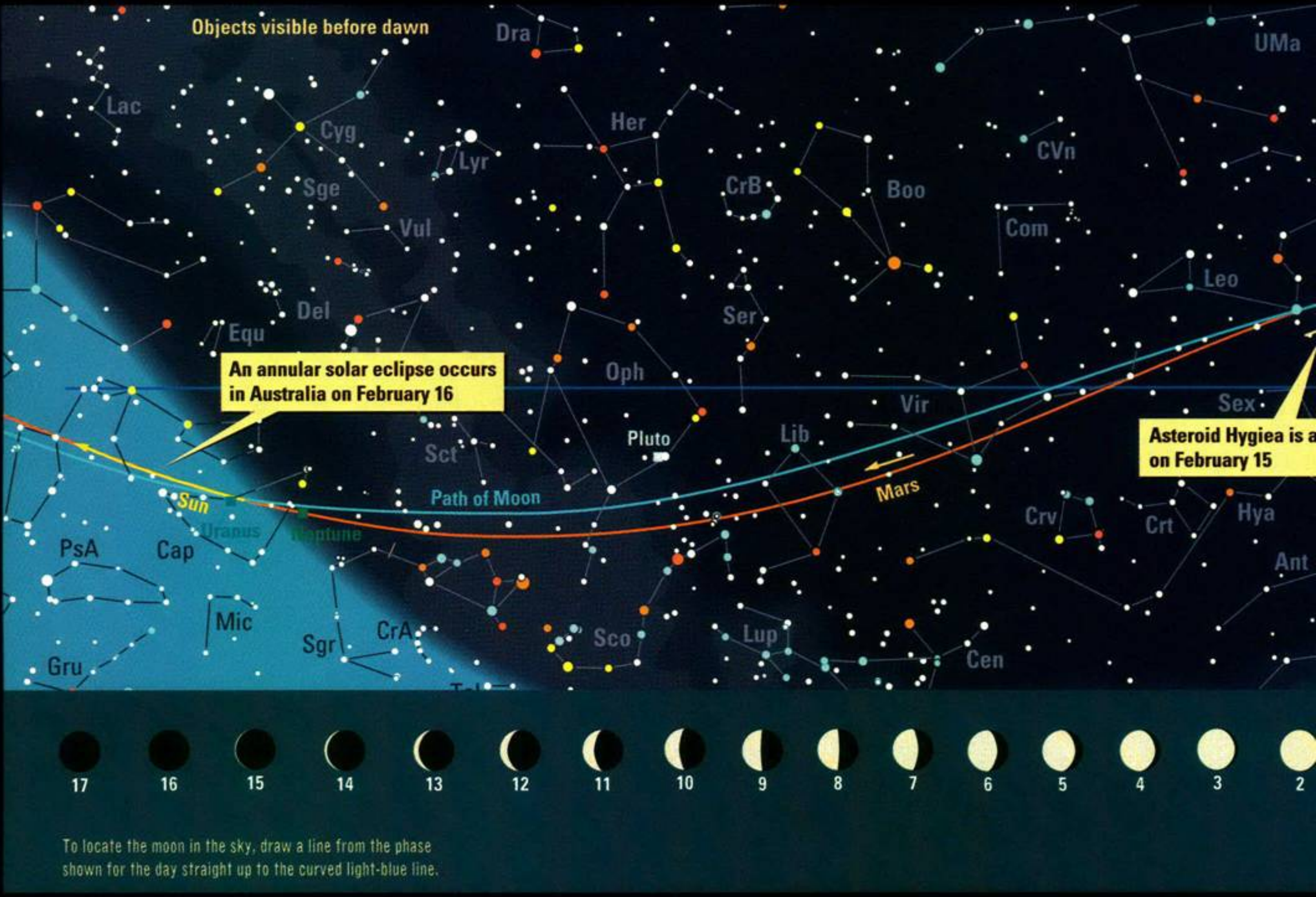
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
DRACO
CEPHEUS
LACERTA
URSA MINOR
Polaris
NCP
Mizar
CASSIOPEIA
ANDROMEDA
M31
PEGASUS
CAMELOPARDALIS
NGC 869
NGC 884
M81
M82
URSA MAJOR
PERSEUS
TRIANGULUM
M33
Algol
LYNX
Capella
AURIGA
M36
M38
M37
Castor
Pollux
ARIES
PISCES
Pleiades
West
Saturn
Ecliptic
TAURUS
Hyades
M1
M35
GEMINI
CANCER
M44
Regulus
Aldebaran
ORION
Mira
CETUS
CANIS MINOR
Procyon
Betelgeuse
HYDRA
MONOCEROS
M42
Rigel
ERIDANUS
M47
Sirius
CANIS MAJOR
M41
LEPUS
FORNAX
PYXIS
Adhara
PUPPIS
COLUMBA
NGC 2477
VELA
CAELUM
HOROLOGIUM
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
10:00 P.M. on February 1
9:00 P.M. on February 15
8:00 P.M. on February 28

Planets are shown
at midmonth

THE PATH OF THE PLANETS


Objects visible before dawn
Dra
UMa
Lac
Cyg
Lyr
Her
CVn
Sge
CrB
Boo
Vul
Com
Leo
Del
Ser
Equ
Oph
Vir
Sex
Sct
Pluto
Lib
Hya
Sun
Path of Moon
Mars
Crv
Crt
Uranus
Neptune
PsA
Cap
Ant
Mic
CrA
Sco
Lup
Sgr
Cen
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17
16
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12
11
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3
2

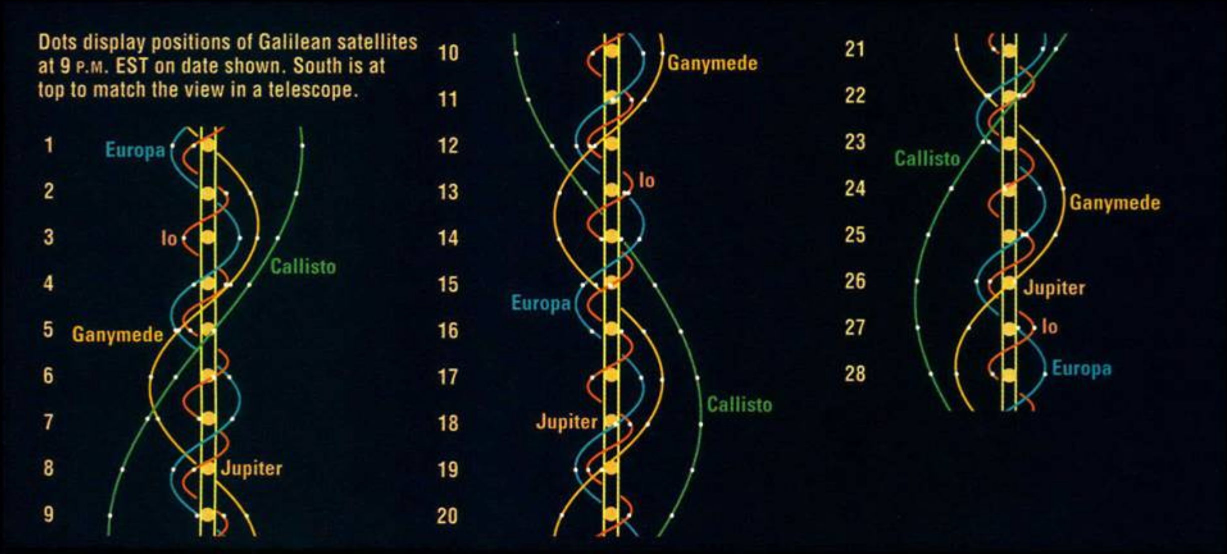
An annular solar eclipse occurs in Australia on February 16

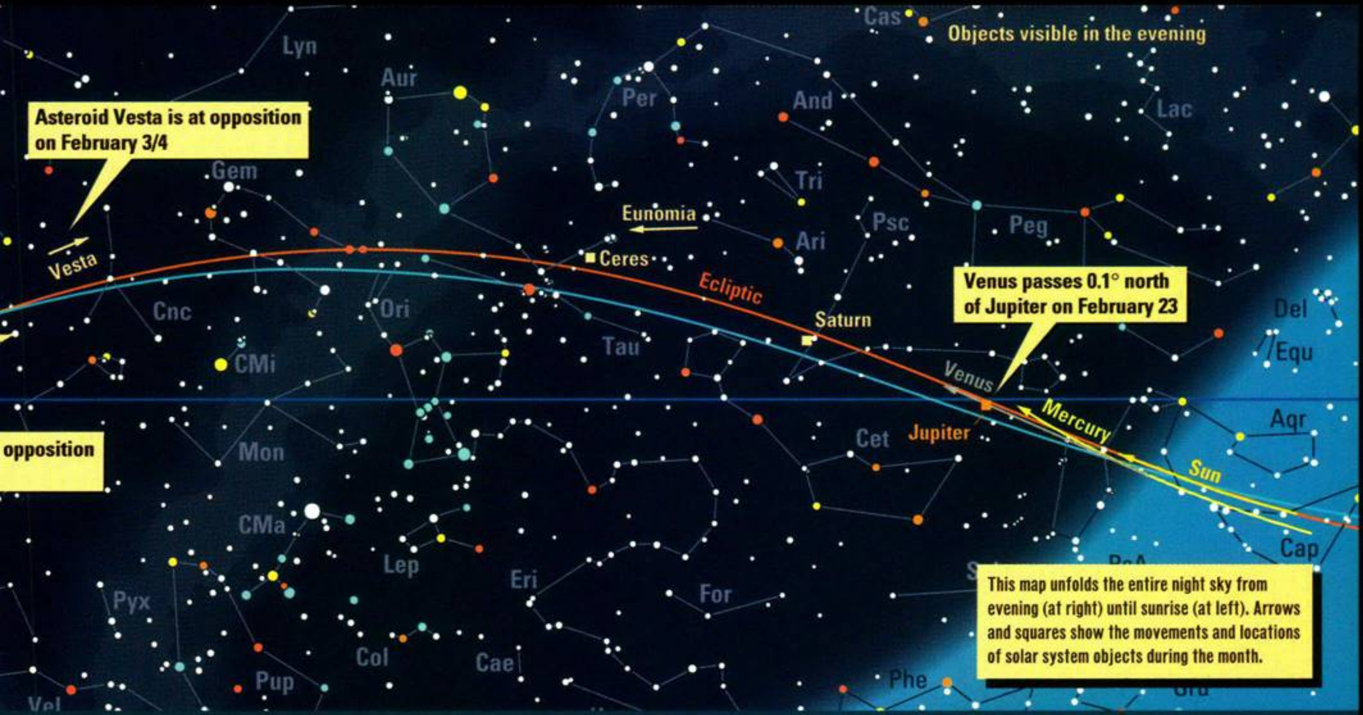
Asteroid Hygiea is a
on February 15

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

10" PLANETS (S, W—E, N)	MERCURY	MERCURY	VENUS	MARS	MARS
Date	February 15	February 28	February 15	February 1	February 28
Magnitude	–1.3	–0.8	–3.9	0.5	–0.1
Angular Size	5.2"	6.6"	11.3"	8.0"	10.2"
Illumination	96%	63%	90%	90%	92%
Distance (AU) from Earth	1.301	1.023	1.474	1.178	0.916
Distance (AU) from Sun	0.357	0.308	0.724	1.655	1.640
Right Ascension (2000.0)	22h27.0m	23h45.6m	23h30.9m	14h03.0m	14h34.2m
Declination (2000.0)	–11°17'	–0°39'	–4°31'	–10°16'	–12°49'

JUPITER'S MOONS


Dots display positions of Galilean satellites at 9 P.M. EST on date shown. South is at top to match the view in a telescope.


Cas
Objects visible in the evening
Lyn
Aur
Per
And
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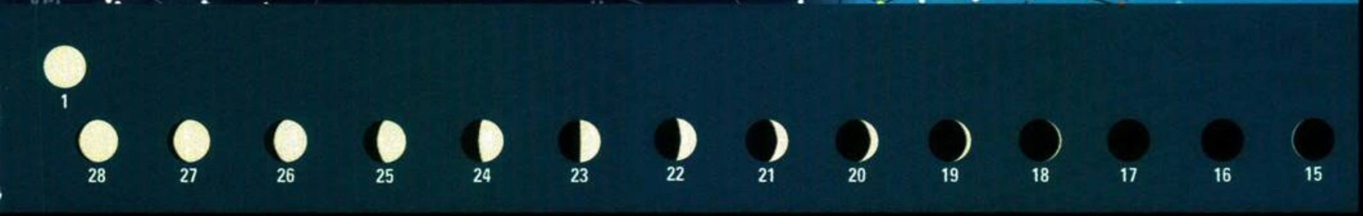
Gem
Tri
Eunomia
Psc
Peg
Ari
Vesta
Ceres
Ecliptic
Cnc
Ori
Saturn
Del
Tau
CMi
Equ
Venus
Mercury
Aqr
Jupiter
Cet
Sun
Mon
CMa
Cap
Lep
Eri
For
Pyx
Col
Cae
Pup
Phe
Vel

Asteroid Vesta is at opposition on February 3/4

opposition

Venus passes 0.1° north of Jupiter on February 23

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.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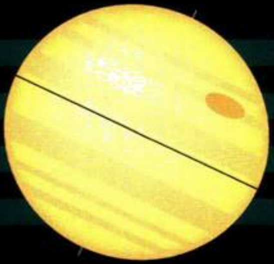
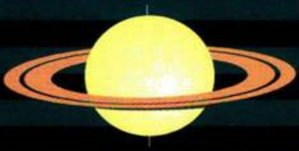
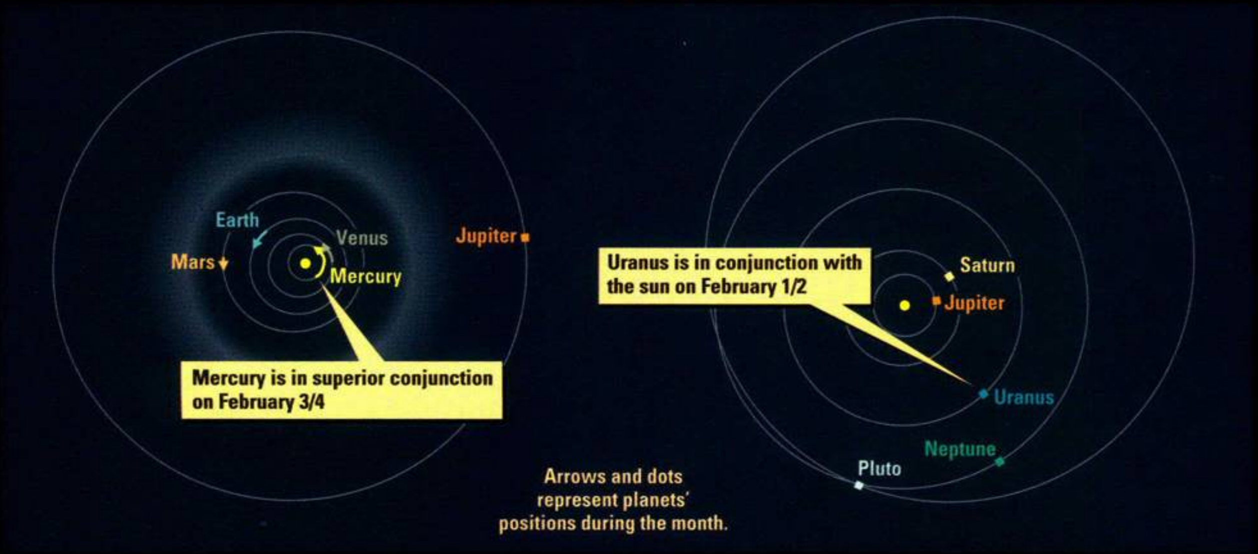



JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
February 15	February 15	February 15	February 15	February 15
−2.1	0.3	5.9	8.0	13.8
34.4"	17.2"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
5.734	9.666	20.855	31.038	30.359
4.953	9.258	19.891	30.132	30.133
0h03.4m	1h50.3m	21h04.7m	20h19.9m	16h41.5m
−0°51'	8°51'	−17°22'	−19°16'	−10°34'

THE PLANETS IN THEIR ORBITS


Earth
Venus
Jupiter
Mars
Mercury
Saturn
Jupiter
Uranus
Neptune
Pluto

Mercury is in superior conjunction on February 3/4

Uranus is in conjunction with the sun on February 1/2

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: The Bright Clusters M41 and NGC 2362

K. Weinberg

George R. Viscome

Some observers falsely assert that star clusters all look the same, but that's not so. Star clusters come in a wide variety of shapes, luminosities, and densities. Each has its own charm, and they are all a delight to look at.

Messier 41 is the perfect star cluster for beginners. It can be seen with the naked eye — Aristotle recorded it as a fuzzy spot — and is easily visible in binoculars from the city. Look for M41 just 4° south of Sirius. The cluster holds ten stars brighter than 9th magnitude, another dozen a bit fainter, and dozens more gradually fading into the fine stardust of the Milky Way.

After absorbing the view at low power, increase the magnification to more than 100x. Can you see the orangy-red star near the middle? How does its color compare to the other stars in the cluster?

In complete contrast to M41 is the tight swarm of stars that make up NGC 2362. Point your telescope toward Tau (τ) Canis Majoris — the tip of Canis Major's tail. At first glance, all that may be seen is a star with a halo. Increase the power to 150x — even with a small scope — to be rewarded with a fine scene. About 30 stars, similar in brightness to those in M41, are packed into a space 25 times tighter. It looks like a starburst of fireworks frozen in space.

There are dozens of clusters in this area of the sky, seek them out and enjoy their differences.

European observers will have a fine view in twilight on that evening. For American observers, this event occurs during daylight hours, and those with telescopes may be able to catch the moment. By nightfall, the two planets will have moved apart slightly, though will still be less than ¼° apart. Below and to the west of the pair, Mercury is gaining ground. It sets more than an hour after the sun.

To round out the early evening's planetary action, **Saturn** can be found some 27° above Jupiter and Venus. Shining at magnitude 0.3, Saturn lies opposite the Jupiter/Venus pair in Pisces the Fish. The growing crescent moon passes 3° south of Saturn on February 20.

The four evening planets — Mercury, Venus, Jupiter, and Saturn — offer some of the best opportunities all year for planetary observation and photography.

The fifth planet visible during February is **Mars**. It doesn't rise until near midnight and is approaching opposition on April 24. By late February, it reaches magnitude 0 and will continue to brighten through April. This month also marks an important milestone in the visibility of surface features. From this point on, the view can only get better.

The arbitrary size of 10" is often used as a guide to determine when useful surface observations can begin. Mars reaches this apparent size by the end of February and will continue increasing until opposition when it spans 16". Mars spends the first half of February moving gently eastward from night to night among the stars of Virgo the Maiden. It then passes into Libra the Balance.

The bright stars of Orion, Taurus, Gemini, and Canis Major dominate the sky once Jupiter and Venus set at around 8 P.M. Though the nights may be cold, it's worth the extra effort to bundle up to see the sights this region of sky brings. From a stellar birthplace in the Orion Nebula (M42) to the Crab Nebula (M1) in Taurus, the winter sky has it all.

Some of the lesser known winter gems are also worthwhile. Take note of M41 in Canis Major the Great Dog. This fine open star cluster is visible in binoculars and lies 4° south of Sirius — the brightest star in the sky. Below Sirius are three stars that form a triangle that represents the hind legs of the Great Dog. A couple of degrees northeast of the triangle's point lies the 4th-magnitude star Tau (τ) Canis Majoris, a fine triple. In addition to this multiple star, a cluster of several dozen stars congregates around Tau CMa. These stars form a truly wonderful sight for small telescopes.

Beneath the feet of Orion and adjacent to Canis Major is dim Lepus the Hare. The brightest two stars, Alpha (α) and Beta (β), point roughly to M79. Often overlooked, this fine globular cluster is just above the southern horizon for most northern observers.

Following a line from Alpha through Mu (μ) Leporis to the west leads the adventurous observer to an unusual star. R Leporis is one of the reddest bright stars in the sky. Since its discovery by John Hind in 1845, R Leporis has been known as Hind's Crimson Star. It's a long period variable that ranges in magnitude from 5.5 to 11.7 over a 427-day cycle. Observers can expect the star to be rather faint this month. Once it reappears in the morning sky later this year, it will have brightened appreciably and its color will be even more noticeable.

Low in the west and just to the southeast of Saturn is Mira, or Omicron (ο) Ceti, "The Wonderful." This star's variations brought it to maximum brightness in December 1998, and it should still be visible to the naked eye.

High above Cetus is Taurus the Bull. The Bull's head is marked by the fine open cluster called the Hyades. Its V-shape not only marks the Bull's head but his horns as well.

The beautiful sapphire stars of yet another open cluster called the Pleiades, or Seven Sisters (M45), lie near the Bull's head. This gathering of stars marks the Bull's shoulder and is best

Light Pillars: A Winter's Gift

One very cold observing night I was surrounded by the strangest northern lights I had ever seen — vertical rays that didn't move. The next day, news items quoted people who thought the aliens had landed and pointed their search beams upward.

Robert Greenler's book *Rainbows, Halos, and Glories* explains this phenomenon. It's due to the combination of streetlights and a frigid air mass full of flat-based ice crystals.

Light from unshielded sources radiates upward and hits the bottom of reflective ice crystals in the atmosphere. The light then reflects back down toward your eye. From your point of view, the light appears to come from behind the crystal as part of a column above the light source. Reflections from thousands of crystals with slightly different orientations combine to make the whole pillar — even when you can't see the source. Temperatures of at least 0° F (–18° C) are needed to see this effect. This is one reason why such events are rare in the more temperate coastal regions.

Alister Ling

The Many Moons of Saturn

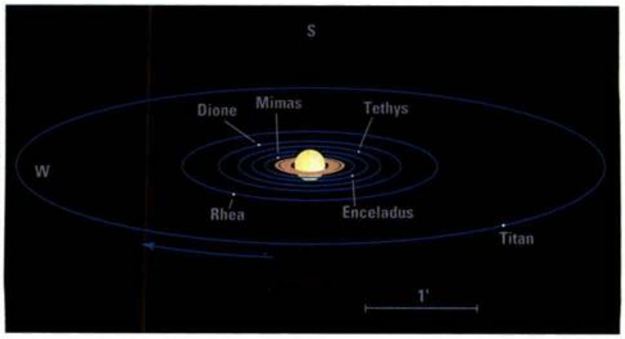
Saturn may have lackluster clouds, but its moons are a delight to watch. The bigger the telescope, the more you can see — a spotting scope can easily pick up Titan, the second-largest moon in the solar system. An 8-inch telescope will handily reveal four more moons. On superb nights, two more inner moons can be seen.

Pinpointing Saturn's moons and identifying them is relatively easy. Many good planetarium software packages can aid you. These programs allow observers to print charts that are inverted and flipped to match the orientation seen in a telescope.

Iapetus is a lone 10th-magnitude speck hanging east of Saturn at month's start. It slowly works its way toward the planet and is at inferior conjunction on February 16. Titan orbits nearly two times in one month, while the other moons move noticeably in the course of a few of hours.

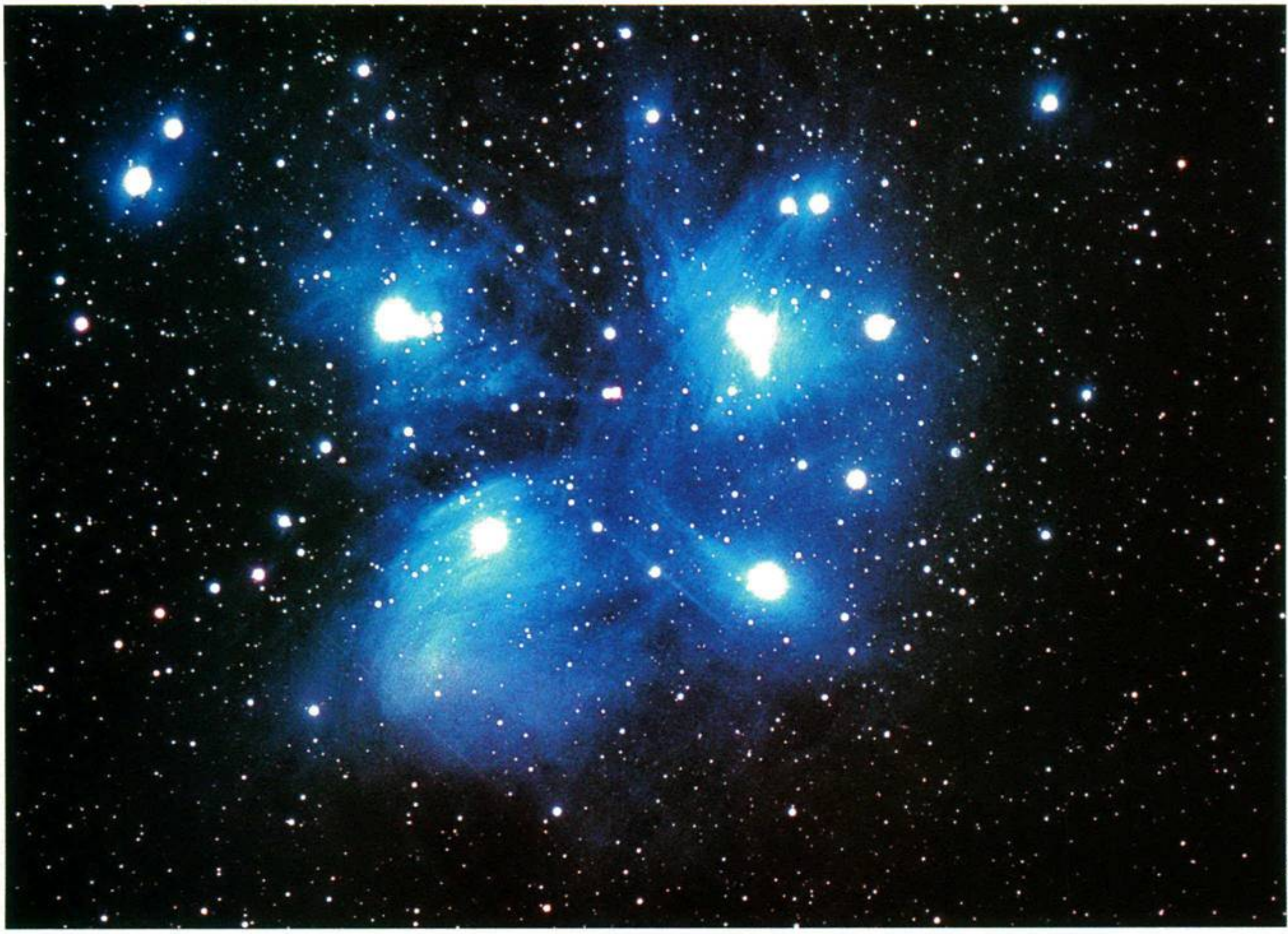
The diagram shows positions of the moons on February 1 at 7 P.M. EST (0h UT on February 2) and the shape of each moon's orbit with an arrow showing which way they are moving. Find the number of days (in Universal Time) that have elapsed since the start of the month, then divide that number by the orbital period of the satellite. The result is how many orbits the moon has completed, while the decimal is the fraction of the orbit the moon has traversed since its starting point. For example, on February 15, at 7 P.M., Dione will have orbited 14/2.737 = 5.12 times. This means the moon will be about 1/10 of the way around its orbit.

The orbital periods (in days) of Saturn's brightest moons are: Mimas 0.942, Enceladus 1.370, Tethys 1.888, Dione 2.737, Rhea 4.517, and Titan 15.945.



All illustrations by *Astronomy*: Elisabeth Rowan

OBSERVER'S CHALLENGE: The Merope Nebula



Tony and Daphne Hallas

The Pleiades (M45) is one of the most photographed objects in the sky and makes one of the top pictures published in books, magazines, postcards, and posters. Can there be any doubt as to why? It's striking, awe-inspiring, and somewhat mysterious. But what makes the picture outstanding are the wisps of nebulosity. Take them away and you've simply got a nice cluster.

Most astronomers jump at the chance to view these delicate tendrils of glowing light with their own eyes. The Merope Nebula (NGC 1435) has almost grown to mythical stature. It was discovered visually by Ernst Wilhelm Liebrecht Tempel with a 4-inch refractor in 1859 and is known as one of the toughest deep-sky objects to spot. In truth, it is tough. But with a little persistence, a few tricks of the trade, and a good night, you too can behold this lovely vision.

Naturally, a clean dark sky is the first requirement, but surprisingly it does not have to be one of those legendary ultra-clear nights. A normal, haze-free 6th-magnitude sky will suffice. This may sound campy, but you need to know where to look, and not just at the Pleiades. As soon as one of the bright Pleiades is in your field of view, your dark adapted eye gets blasted by the bright light and the inevitable dust or start of condensation scatters a large halo around the star. Try using one eye to get the field just right, and then switch to your regular observing eye to spot the nebulosity around Merope: The bright star at lower left in the above photo.

Approach the star Merope from the south without letting it into the field of view. This is the star at the lower left of the Pleiades' bowl. Photos show its nebulosity extending farther out than any other, and you should see a ghostly swath of pale light — as Tempel put it, "like breath on a mirror." If the only time you see nebulosity is in a circular patch around a bright star, try again on a better night or after a little rest. What you're seeing is scattered light and not the nebulosity.

As your skill improves, you'll need to boost the power to see the nebulosities. If you consider yourself an expert, take the extra challenge to detect E. E. Barnard's small cometary nebulosity buried in the Merope Nebula. It is very close to the star itself.

viewed through a pair of binoculars or a small telescope at low power. The scene is always breathtaking.

High above the Pleiades and passing overhead is Auriga the Charioteer. The constellation not only houses 0-magnitude Capella, but the dim inner reaches hold three of the finest open clusters in the sky — M36, M37, and M38. Because the Milky Way runs through the region, open clusters abound in it. Open clusters form in gas clouds within the galaxy, so they are also called galactic clusters.

The winter Milky Way is not as bright as its summer counterpart. During the winter months we see the outer spiral arms of our galaxy. These arms lie farther from the Milky Way's center than we do. When we look at the summer Milky Way, we look toward the central, denser regions of our galaxy.

Rising in the east is regal Leo the Lion. Leo is clear of the horizon by 10 P.M. in February. Between Leo and Gemini the faint constellation Cancer the Crab houses another open cluster. Best known as the Beehive Cluster, or M44, it is also called Praesepe. This fuzzy naked-eye patch of light is a fine sight in binoculars or a low-powered telescope.

The 6.2-magnitude asteroid 4 Vesta lurks about in Cancer this month. Its brightness technically makes the asteroid a naked-eye object under ideal sky conditions. But use binoculars first and look in the northeastern part of the Crab.

On February 4, Vesta lies directly opposite the sun. The star Xi (ξ) Cancri will aid the search. Vesta can be found a mere 2° east of the 5.1-magnitude star.

Venus Joins Jupiter

John McNeal

For months Jupiter has been the brightest planet after darkness falls in the evening sky, but this month Venus competes for the evening spotlight. Watch this month as the pair nearly merges in the twilight glow.

This is a perfect opportunity to catch the public eye and point it to the sky. So mark your calendar, organize a public star night, call the newspapers, or do TV interviews. Hale-Bopp may have fired people's imaginations, but no one can resist the sheer beauty of this impressive gathering. So don't miss the spectacle.

As February opens, Jupiter still commands the evening sky with fainter Saturn resting higher. The unsuspecting public may not have seen Venus struggling against the horizon's glow the past couple of weeks. It suddenly vaults toward Jupiter this month — creating a spellbinding double evening star.

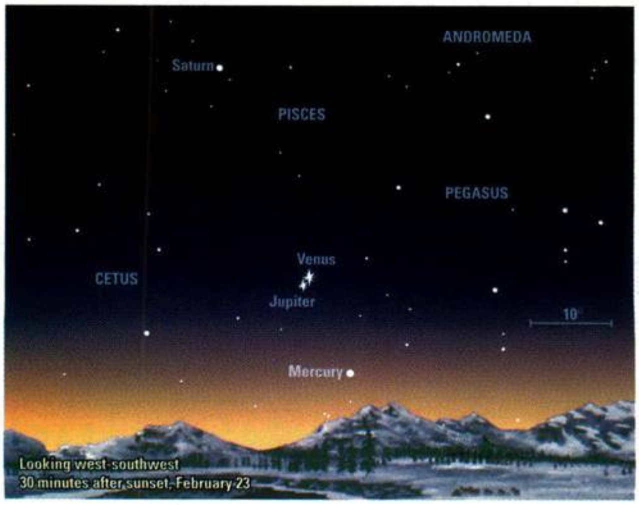
On February 17, a breathtakingly thin crescent moon filled with ashen light hangs 5° below Venus — just enough to squeeze both into a binocular field. By February 18, Europeans will see all three objects in one binocular field. For North Americans, the gorgeous crescent moon will have moved up and to the left (east) of Jupiter.

If this isn't enough, Jupiter and Venus swap places as they graze a mere 12' past each other on February 23. That's less than half the width of the moon. Their relative speed is amazing. Only one day before or after the close encounter, the planets are separated by nearly two whole moon widths.

Photos of this event are easier to take than you might think. Use a slow fine-grain film. That way you will be able to make poster-size enlargements once the film is developed. Try an ISO 100 film and shoot with ordinary lenses using a tripod. Start with an exposure of 1/15 second at f/2.5. Take your images when the twilight colors are at their best.

It is crucial to shoot a range of exposures. This ensures at least one that's just right. Film is cheap. Shoot a whole roll at different stages of twilight early in the month to see what works best. Keep careful notes of the time of day as well as the exposure and f/stop. Though these notes will help, remember that the sun sets later as the month progresses. One quick rule of thumb, read the exposure your light meter suggests but shoot at least four times faster. If the light meter says 1 second, shoot at ¼-second.

Be creative. Try multiple exposures, use interesting foreground trees or buildings, try different tele-photo lenses. The next time such a beautiful group gathers is June 2002, and it won't be as stunning. The planets will be lower in the brighter twilight. (Also see "Venus Rising," page 80.)



Mars Approaching Opposition

When it comes to visible surface markings, Mars has the other planets beat. Although the globe of Saturn appears twice as wide as Mars's this month, the rusty colored 9"-diameter disk displays far more detail than the nearly featureless cloud bands of Saturn.

Mars is only two months from its opposition in April. That's when it will reach its greatest apparent diameter (16") and be visible all night. This will be our best view of Mars since 1990.

As February opens, Mars rises at midnight. The planet's bright, red color is easily spotted in the dim stars of Virgo. Mars lies just to the east of Virgo's brightest star, Spica. Watch as the separation between the two increases as the month progresses.

The more often you look at Mars through a telescope, the easier it is to see tiny details on the martian surface. So hone those skills. Besides watching the planet's ice caps gradually change size, try to identify the dark markings and check the pale yellow areas for featureless lighter patches — signs that a dust storm is in progress. The trick is to get up early or stay awake until the early morning hours. Mars reaches the meridian at about 5 A.M. local time.

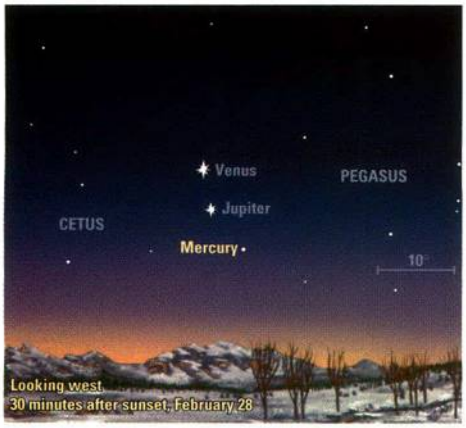
Donald C. Parker

While you're flexing your detection abilities, note the phase of the moon as it passes by on the morning of February 6 — last quarter. Next month, the moon will be a bit fatter when it passes Mars.

Solar System Boogie

Mercury has a great display late this month. Certainly the Venus/Jupiter conjunction will outshine the speedy innermost planet, but the dazzling duo will actually help in the search for elusive Mercury.

On February 23, the closest approach of Venus and Jupiter, Mercury will be a modest naked-eye sight 4° above the western horizon one hour after sunset. The planet shines at magnitude –1.0 in deep blue twilight. A view through the telescope shows a small, gibbous phase, 77 percent lit.



By February 28, Mercury will be halfway between Jupiter and the horizon. It forms a nearly evenly spaced but crooked line with the other two planets. At this point, Mercury is starting to lose some of its brilliance. Though its apparent disk size is growing, the planet's phase is shrinking. Mercury is moving closer to the half-moon or one-quarter phase. On February 28, a 6.8" disk will hold a 58-percent-lit phase. One week later, Mercury is easily spotted 5° to Jupiter's right (north).

Mercury is also at perihelion (closest point to the sun) on February 28. Can you determine its orbital position relative to Earth, Jupiter, Saturn, and the sun by what is seen in the sky?

Asteroid 10 Hygiea reaches opposition this month as well. Hygiea is at magnitude 9.7 in Leo on February 15. Although faint, an ideal opportunity to spot the asteroid occurs a few days before and after February 23. On that date, Hygiea passes close to the 4th-magnitude star Omicron Leonis. Plot the field of view for three nights. The asteroid will reveal itself by its motion with respect to the star.

Rising with Leo is Ursa Major the Great Bear. Its bright asterism, the Big Dipper, dominates the northeastern sky. This large, well-known group of stars holds many deep-sky gems. The Owl Nebula (M97) can be found here, along with the fine naked-eye double Mizar and Alcor. Fine galaxies such as M81, M82, and the beautiful face-on spiral M101 are here as well. To top things off, the constellation is visible all night.

An annular eclipse of the sun occurs across the Indian Ocean and Australia on February 16. Although the moon exactly lines up with the sun, it is also near its farthest orbital point from Earth. This makes the moon's disk a bit too small to block out all of the sun's disk. At mid-eclipse, a ring, or annulus, is visible around the dark limb of the moon — hence the name annular eclipse. Eye protection is required for viewing all phases of the eclipse. The central track passes north of the Australian city of Perth. A

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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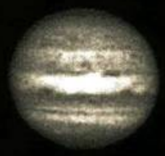

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- The stepper motor drive electronics are cordless and operate on two 9 volt batteries.
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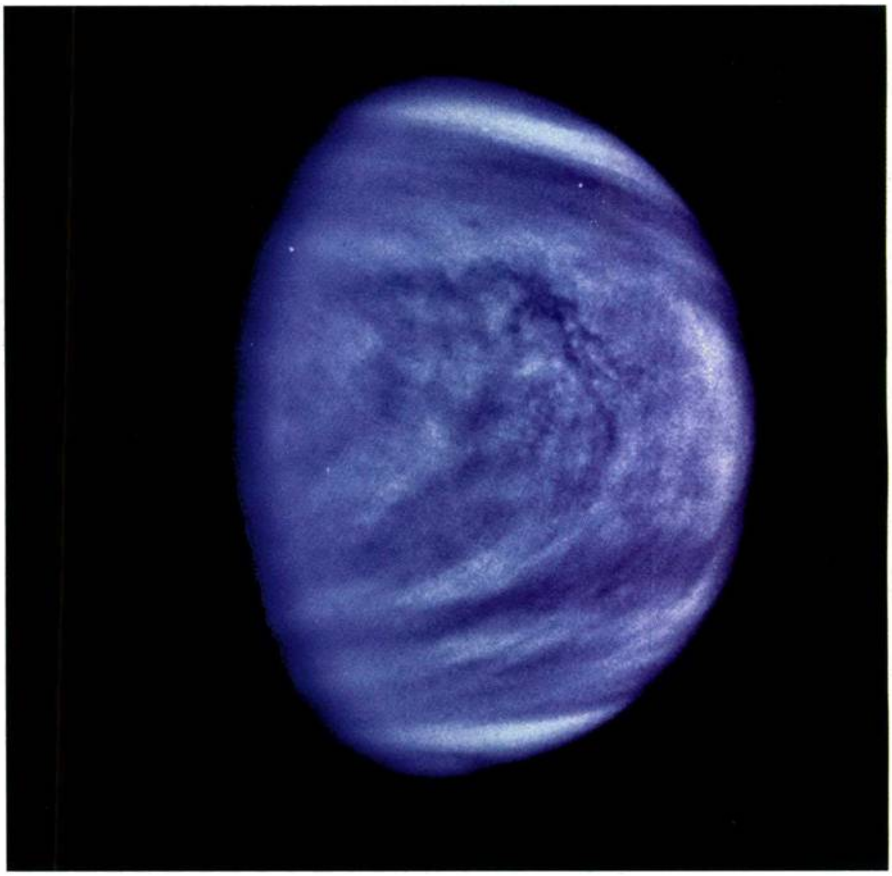
Kids' Corner

VENUS RISING

Spend time "discovering" Earth's neighbor with your kids.

by Andrea Gianopoulos



Captured by the Galileo spacecraft on its way to Jupiter, this colorized and filtered image reveals fine detail in the planet's sulfuric acid clouds. Galileo/NASA/JPL

"STAR LIGHT, STAR BRIGHT, first STAR I see tonight." Well ... not quite. That brilliant beacon hovering above the western horizon is most likely a planet. For the last few months Jupiter has dominated the evening sky. This month, Venus adds her dazzling beauty to the scene, giving parents and teachers the perfect opportunity to begin an observing project with their charges.

Venus is the brightest planet in the sky. With a magnitude of –4, it's an easy target to find. This year's apparition has the added benefit of offering three other planets to watch. Venus overtakes Jupiter in February, and it passes Saturn in March. Mercury joins the threesome in late February.

Use this gathering of bright evening objects to teach basic observational skills. Start by keeping a record of Venus's motion. Plot its ascent from the horizon to its meeting with Jupiter on February 23 (see "Venus Joins Jupiter," page 76). Every three or four days measure the separation between the two planets. No slide rules or sextants are needed, just use your

The Kid Connection

Send your artwork, poems, riddles, and questions to Kids' Corner, *Astronomy* magazine, P.O. Box 1612, Waukesha, WI 53187-1612, or e-mail kids@astronomy.com. Test your knowledge with *Astronomy's* online quiz at http://www.astronomy.com.

hands. How many fists or fingers at arm's length separate the pair? (On average, one finger's width at arm's length is 2° and a fist from pinky to thumb is roughly 10°.) Draw each night's scene on a piece of graph paper — one square can represent one finger's width. Also measure each planet's distance above the horizon and be sure to record the time at which the measurements were taken. For the most dramatic effect, take measurements at roughly the same time each evening. Doing this highlights the eastward motion of Venus relative to Jupiter and the horizon. Making observations at different times each night allows Earth's daily motion to creep into the results.

The truly ambitious can also plot Saturn's position. In fact, the distance between Jupiter and Saturn offers a stately contrast to the more rapidly changing separation between Jupiter and Venus. If interest is high, you may wish to continue the project past the February 23 Venus/Jupiter encounter. On March 20, Venus will pair with Saturn. A four-day-old crescent moon also joins the show.

Those who want to spend the time can watch Venus alter her face through July. The next few months find Venus moving from a fat gibbous phase to a thin crescent. At the same time, the planet's disk seems to grow in size. Such changes are the result of Venus's changing position relative to Earth and the sun. As the two planets approach one another, Venus appears to grow in size while its phase shrinks.

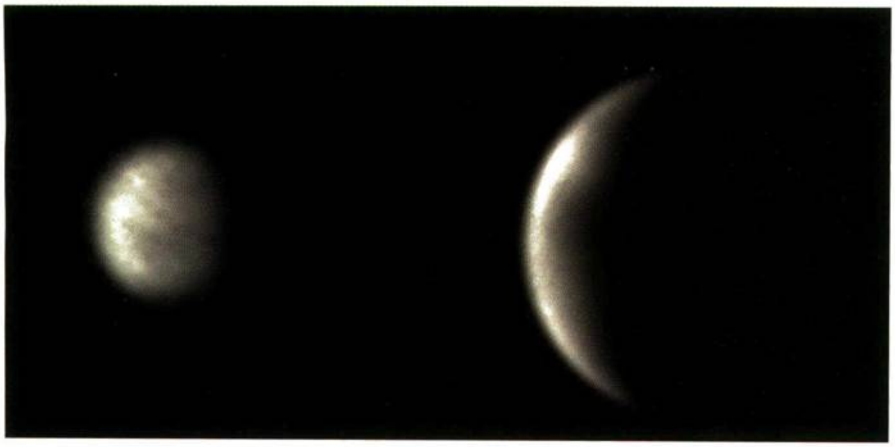
On February 1, Venus is 92 percent illuminated and 11" across. Two months later, a 79-percent-lit gibbous is on a disk 14" across. This gradual trend of shrinking phase and growing disk size continues until July when Venus and Earth approach each other rapidly. In just one month, the phase shrinks from 37 percent to a thin 10-percent-lit crescent, while the disk grows from 30" to 50" across.

These phase and size changes reveal Venus's position relative to Earth and the sun. Older children, and even adults, may want to map orbital positions from the information gathered through the eyepiece. Where are Venus and Earth relative to the sun if Venus is showing a thin crescent or a gibbous? How would Earth's disk change if observed from Venus?

Exercises like these help convey the link between the mechanics of the solar system and what is seen through the eyepiece. With a little commitment and some patience, your child can "discover" the changing face of Venus in the same way early astronomers did several hundred years ago.

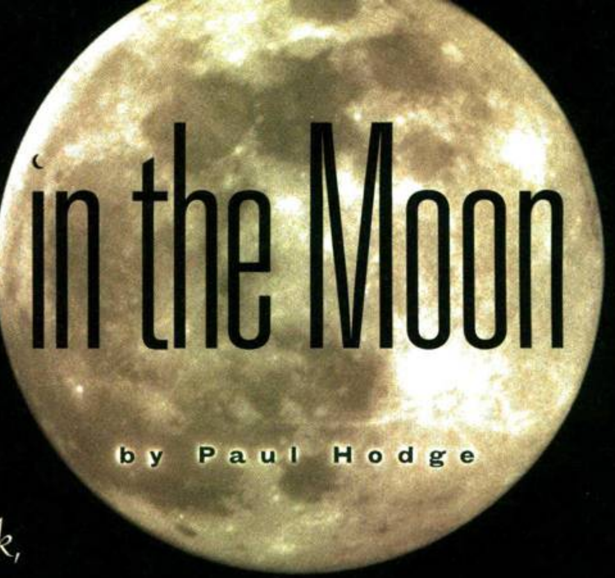
Fun Facts

- **Venus can be as close to Earth as 24 million miles. Only the moon comes closer, by about 100 times.**
- **It takes 224 Earth days for Venus to revolve around the sun one time.**
- **Venus rotates on its axis, with respect to the stars, once every 243 Earth days.**
- **On Venus, the sun rises in the west and sets in the east. The planet rotates in the direction opposite to that of Earth's rotation.**
- **A venusian day — sunrise to sunrise — is 117 Earth days long.**
- **Venus is the planet whose orbit is closest to a perfect circle.**
- **The thick clouds of Venus reflect 65 percent of the light received from the sun — more than any other planet in the solar system.**
- **Jupiter's Great Red Spot would hold three Earths.**
- **The darker the color of Jupiter's clouds, the deeper they are in the atmosphere.**
- **Jupiter would hold more than 1,300 Earths.**
- **Saturn, the second largest planet in the solar system, would hold more than 750 Earths.**
- **How much would you weigh on Venus? To find out, multiply your weight in pounds by 0.9. On Saturn, you would weigh 1.06 times more, and on Jupiter, your weight would increase by 2.53 times.**



As Venus and Earth move closer, the disk of Venus appears to grow in size while its phase shrinks. This changing face is easily seen in modest telescopes and large binoculars mounted on a tripod. Donald C. Parker

Naming the Man in the Moon



by Paul Hodge

Want a lunar crater named after you? It certainly helps if you are an ancient Greek, or a famous, dead, male astronomer.

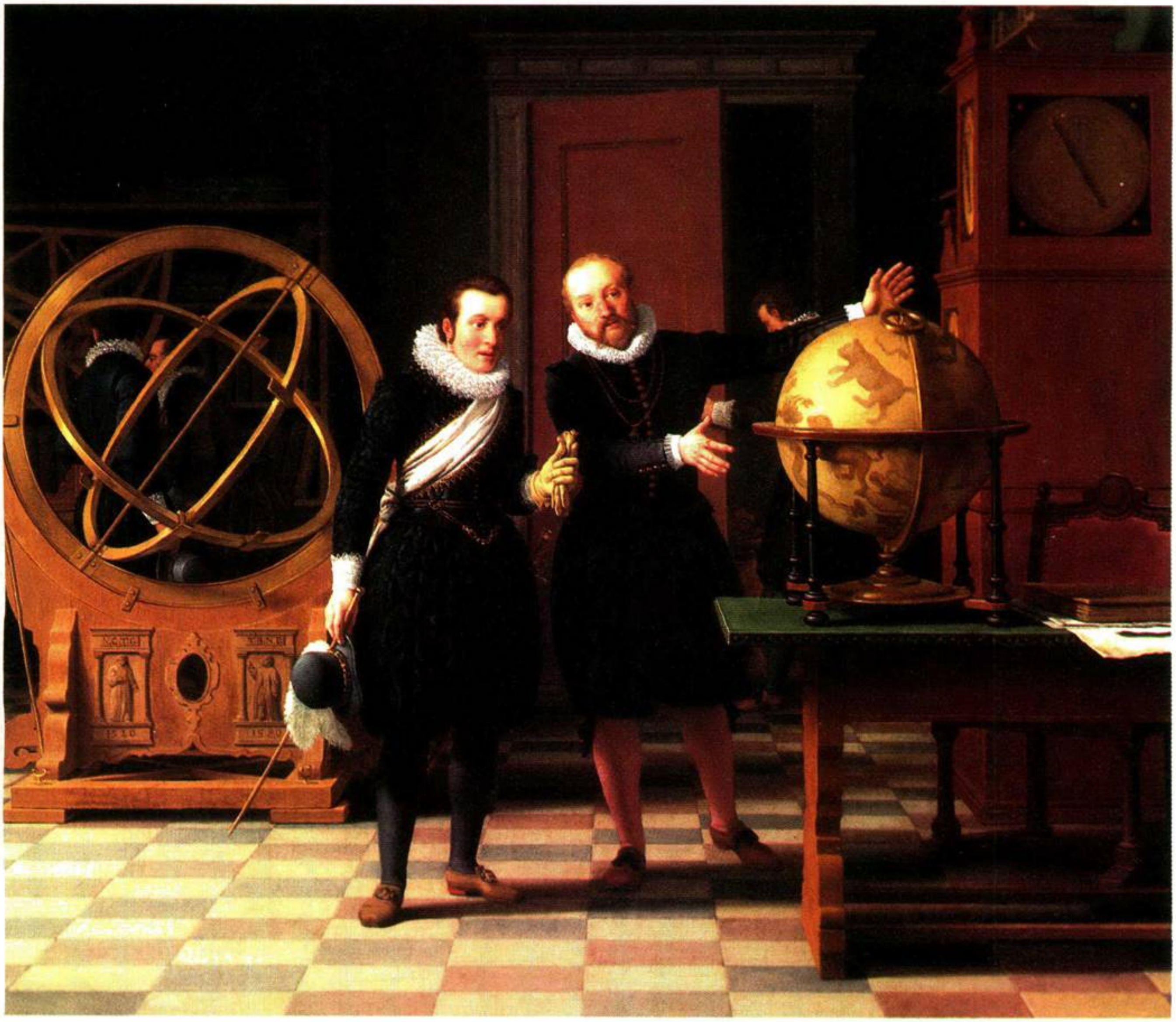
The "man in the moon" of my childhood, that splotchy pattern of dark-lava flows and chalky highlands, actually reminds me of a woman: a glowing, cameo silhouette of Whistler's mother. And why not? In Roman times the deity personified by the moon was feminine — Luna — and many of my female friends instinctively identify with her 29.5-day revolution cycle.

However, lunar cartography reflects those who named the orbiting orb's features and those who dominated the early eras of science. Indeed, when it comes to the modern moon, it helps if you were an ancient Greek or a famous, dead, male astronomer.

Astronomy's claim on the moon, and the need to name her landmarks, has resulted in a unique history of science from an astronomical perspective. Those who mistakenly favored heliocentrism and a flat Earth are memorialized alongside Newton, Darwin, and Einstein. Not unexpectedly, the father of astronomy dominates lunar geography. Copernicus, the 58-mile (93-km) crater of the western plains, is one of the grandest features, with rays that splay out hundreds of miles in all directions. Nicolas Copernicus was the Polish astronomer who showed how much easier it would be for Earth to go around the sun than the reverse. His theory changed everything. On the other hand, Kepler is a smaller 19-mile (30-km) crater west of Copernicus, named for the astronomer who in the early 17th century discovered the mathematical nature of the planets' motions. His discovery helped Isaac Newton discover the law of gravity, which explains the motion of planets in the solar system.

The naming of the moon's features began centuries ago. Craters were named and renamed. Even the International Astronomical Union (IAU), the group that now regulates the naming of lunar craters, has occasionally sidestepped its posthumous requirement. Take, for example, Armstrong, the crater named after Neil Armstrong, the Apollo-11 astronaut. The crater is one small step for bending the rules, and one giant leap for mankind.

Nelson Falsarella

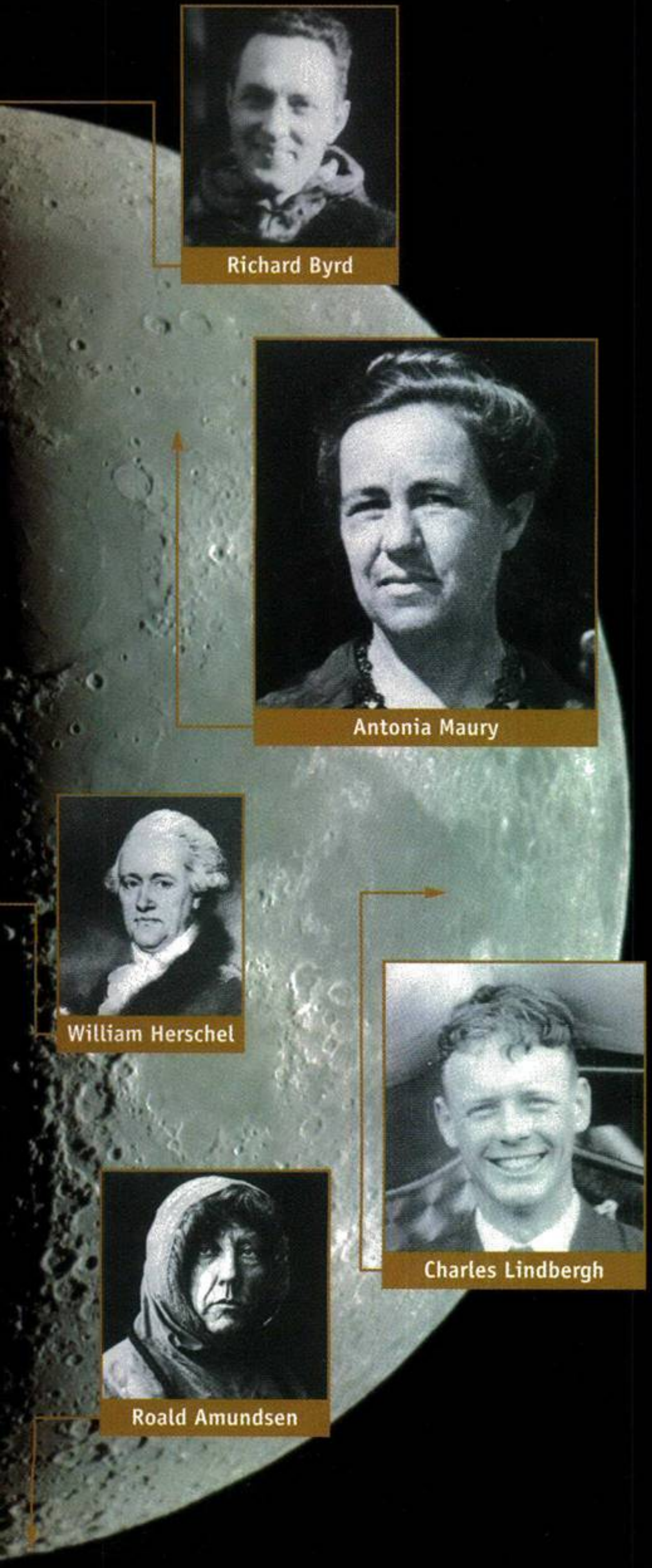


This C. F. Eckersberg painting shows the Danish King Christian IV visiting Tycho Brahe in 1592. Lunar crater Tycho is named after the 16th-century astronomer. Tycho Brahe Planetarium

About 20 lunar craters are named after women. The 18th-century German astronomer Caroline Herschel is there. She discovered nebulae, clouds of interstellar gas and dust, as well as eight comets. She also helped her brother, William Herschel, discover the planet Uranus. A crater is named after Annie Jump Cannon, a Harvard astronomer and among the first to systematically classify stars. Another is named after Agnes Clerke, an astronomy writer who once wrote of a Leonid meteor shower: "On the night of November 12–13, 1833, a tempest of falling stars broke over the Earth." There also are craters named after less well-known women who deserve to be better known: Antonia C. de P. P. Maury, a prolific Harvard spectroscopist; Mary Blagg, a lunar scientist who was instrumental in establishing the list of official names for lunar features; and Louise Jenkins, a Yale astronomer and editor of the Yale Bright Star Catalog. The far side of the moon has crater Leavitt, named for Henrietta Swan Leavitt, a Harvard astronomer who studied variable stars called Cepheids. With her findings, Edwin Hubble and others discovered that the universe is expanding.

Mary Somerville, the Scottish physicist, is there, so is two-time Nobel Prize-winning chemist Marie Curie, who is recognized on the lunar far side by the crater Sklodowska, her maiden name. The 18th-century French mathematician Madame Lepaute (Nicole-Reine Etable de la Briere Hortense Lepaute) has a small crater named for her in the southern lunar highlands.

This lunar memorial garden rotates at exactly the same rate as it revolves around Earth. It's called a synchronous rotation — the moon continually presents the same face to us. This hemisphere is about the same area as the continental United States. And like a real cemetery, the lunar real estate available for names has dwindled. Albert Einstein, the originator of relativity theory, and



Photographs courtesy of, top to bottom,
University of Michigan,
Harvard College Observatory,
Yerkes Observatory,
San Diego Aerospace Museum,
University of Michigan.

Hubble, arguably this century's greatest astronomer, are commemorated by two craters so ill-placed on the margin of the lunar face that they are virtually impossible to see from Earth.

A quirk of lunar motion, called libration, brings Einstein into our line of sight on occasion, but it is very difficult to see with an ordinary telescope. This libration, or "swinging," effect works like this: The moon's rotation on its axis is constant, but its orbital velocity around Earth is changing constantly; slowing at the moon's farthest point (apogee), and speeding up at its closest point (perigee). As the steadily rotating moon passes by at its fastest speed it reveals a small slice of its dark side just beyond its western limb. At its slowest speed we are exposed to a small slice of its dark side just beyond its eastern limb. Instead of presenting 50 percent of her surface to us, the moon actually reveals about 58 percent. If you want to stretch the libration point further, another one percent of the moon would be visible if we could take advantage of Earth's size and watch the moon simultaneously from its arctic and Antarctic regions, and from opposite points along its equator.

Galileo discovered that the moon is cratered, but he let others map it. The early years were chaotic: The names of craters changed with each successive mapmaker. One mapper, M. van Langren, a Belgian mathematician, came up with an idea that persisted: In 1645, he named the craters on his lunar map after astronomers. Years later he himself was honored. The 17th-century Polish astronomer Johan Hevelke began the custom of naming lunar mountains after terrestrial ranges; hence we now have the lunar Alps, the Apennines, the Carpathians, and the Caucasus.

Craters are the most abundant lunar features. They have always borne human names. The 17th-century Italian philosopher Giovanni Riccioli named hundreds of craters. Those in the north were named for the most ancient honorees and those in the south went to the more recent. Thus, Riccioli's lunar map is a historical timeline, read north to south. The 62-mile (100-km) crater Plato was named for the fourth-century B.C. Greek philosopher who championed a system of reality that went beyond human senses. The equally prominent Tycho, in the south, was named for Tycho Brahe. This 16th-century Danish astronomer's precise measurements of planetary positions enabled Johannes Kepler to discover the laws of planetary motion.

Riccioli's historical system was abandoned in the following centuries, but many of his conventions for naming craters continued. The German lunar mapmakers Johann Schröter, Wilhelm Beer, and Johann Heinrich Mädler were responsible for hundreds of the names we now use for lunar craters. The three eventually were memorialized as well.

The far, unseen side of the moon was photographed by the Apollo spacecraft, the Lunar Orbiters, and most recently the Clementine Mission. Thousands of new craters were discovered, but since there were only a few hundred famous dead astronomers whose names had not yet been used, the IAU had too few names.

Even early lunar cartographers resorted to names from other scientific disciplines, including chemistry and biology, physics and philosophy. They also delved into classical Greek and Roman history for more names.

Mathematicians have done well on the moon, probably because astronomy leans so heavily on their work. For instance George Boole, a

19th-century Englishman whose Boolean algebra is important to modern computer scientists, has a crater named after him. However, Boole is virtually invisible from Earth, lying at the far northwest corner of the moon. Not far from Boole, larger and a little easier to find, is another crater. It is Babbage, named for the 19th-century English mathematician and inventor Charles Babbage. He is the father of the modern computer.

In addition to the physicists Somerville and Curie, there are craters named after Newton, Michael Faraday, and James Watt. The crater named for Charles Darwin, the 19th-century English biologist and author of *The Origin of Species*, sits near the crater named after Jean-Baptiste Lamarck, the French zoologist whose major accomplishment was the division of animal life into the vertebrate and invertebrate categories.

At the bottom of Mare Fecunditatis lies Colombo, named for Christopher Columbus, and Cook, named for Captain James Cook. In the same lunar sea but closer to the equator is Magelhaens, named for Ferdinand Magellan, the seafaring circumnavigator, and Lindbergh, named for Charles Lindbergh, the American aviator who pioneered transatlantic flight.

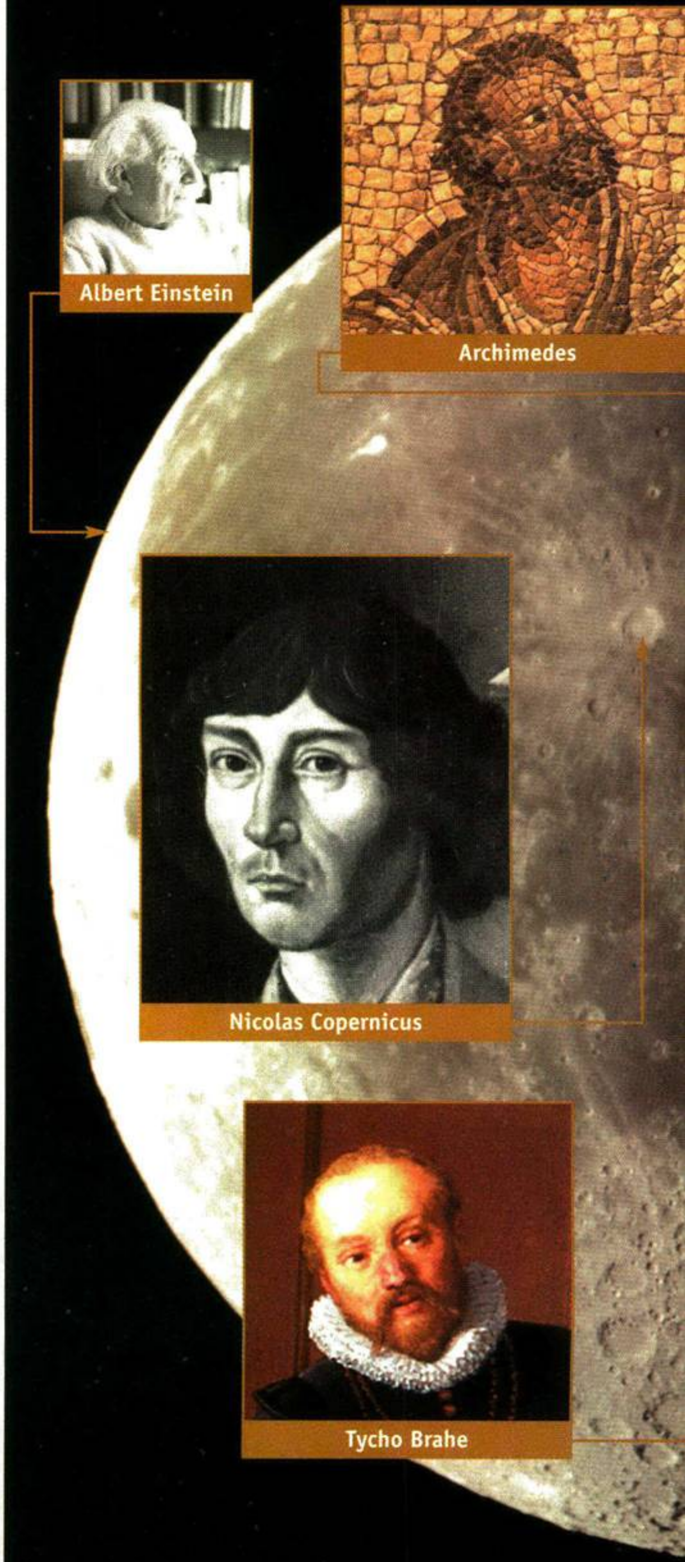
Earth's polar explorers are appropriately remembered at the lunar poles: Amundsen and Scott are 62-mile (100-km) craters at the lunar south pole. Roald Amundsen, a Norwegian explorer, won a dramatic race in late 1911 to be the first person to reach the south pole. The craters Nansen and Byrd lie near the lunar north pole. Fridtjof Nansen was another Norwegian explorer, whose ship, the *Fram*, penetrated farther north than any predecessor. It was locked in the polar ice in 1895, only a few degrees from the north pole. Richard Byrd was an American aviator who is said to have been the first to fly over the north pole.

In 1970 the IAU broke its rules and assigned the names of twelve astronauts and cosmonauts to lunar craters. The best known are Armstrong, Aldrin, and Collins, the three Apollo-11 astronauts, the first to walk on the moon.

A few well-known political figures are commemorated because of their scientific, not their political, achievements. Caesar is a large, ancient crater near the center of the moon, named for Julius Caesar, who improved the calendar. A younger crater in the northern highlands is named Franklin, after Benjamin Franklin, the American statesman whose famous kite experiment helped prove the electrical nature of lightning. Sir Thomas Brisbane, a Scottish politician, soldier, and amateur astronomer, has a crater named in his honor — Brisbane. It stands guard near the "shore" of Mare Australe.

Although many named craters are difficult, if not impossible, to see with a modest telescope from the ground, hundreds of them can be found. It is an entertaining and enlightening sport to find the craters that have some special significance. Sharp-eyed observers will have a challenge to find some of these craters, but the experience of exploring the friendly lunar face can be a pleasure, especially when it has names you know that are tied to memories you treasure.

Paul Hodge is chairman of the Astronomy Department at the University of Washington in Seattle, editor of The Astronomical Journal, *and a member of* Astronomy's *editorial advisory board.*



Photographs courtesy of, top to bottom,
Drexel University,
Institute for Advanced Study,
The Copernicus Society,
Tycho Brahe Planetarium.

Make the Most of

5005 EPP
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A galaxy of add-ons make using this small scope an absolute joy.

WHETHER THE PRODUCT IS AN AUTOMOBILE or a telescope, accessories for it are often produced by other firms. In the case of a good product, the list of accessories is long, and so it is with Meade's ETX telescope.

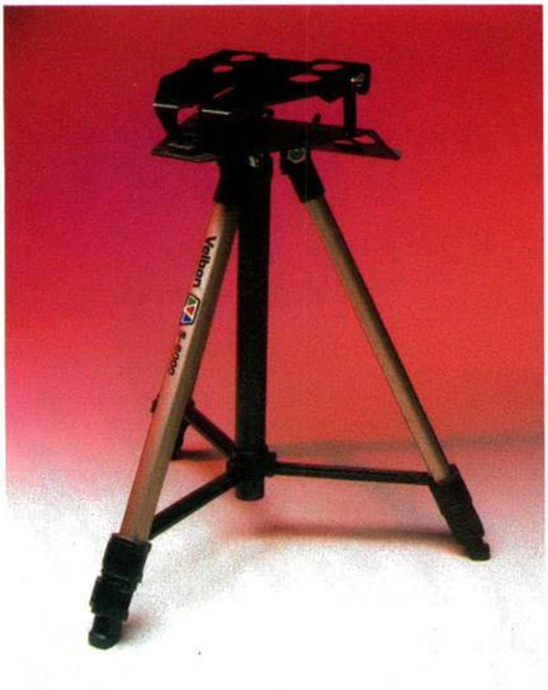
The Meade ETX is a 90mm f/13.8 Maksutov-Cassegrainian telescope mounted on a battery-powered clock-driven fork mount. It makes a small, easily transported package for use in the backyard or out in the field. Four manufacturers responded to a solicitation to review their products.

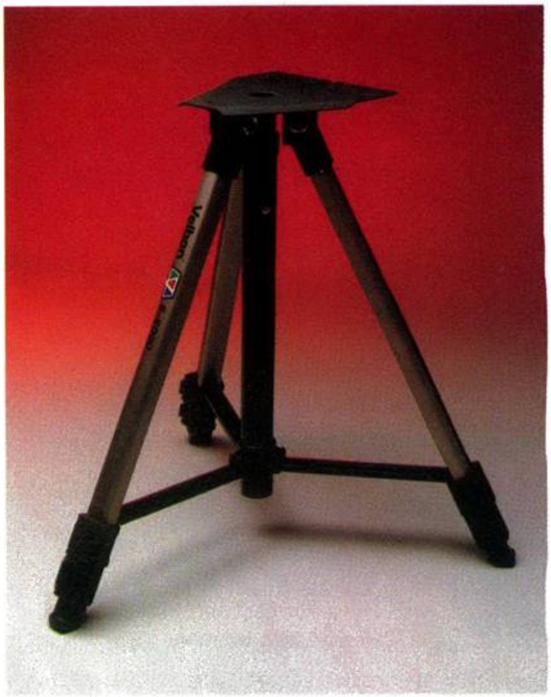
— Tripods —

The ETX comes with legs to use for tabletop polar alignment but most serious users will want a sturdy tripod. JMI has modified the Velbon S-6000 photographic tripod for the ETX. It includes flip locks on the legs for quick setup and takedown and has reinforcement bars that connect to a sleeve that slides on the centerpost. Platform height is not adjustable at the centerpost.

Three options are offered by JMI. You can purchase the wedge/tripod ($119 + $119), the "wedgepod" (a prototype was delivered, $189), or the wedge only ($119) and supply your own tripod. The wedge/tripod combination is a sensible choice if you use the ETX in altitude-azimuth for terrestrial observing as well as for astronomical use. The mounting platform on the tripod is large and flat. The wedgepod permanently mounts the wedge on the tripod, although the wedge must be folded down in order to level the instrument in the altaz mode. To polar align, everything must be moved to adjust azimuth. Tap tests on the tripod legs and wedge assemblies showed damping in two seconds or less.

The wedge, with its spirit level, can be mounted on other tripods using either ¼-inch or ⅜-inch (pre-





Left to right: JMI's prototypical "wedgepod" mounted on a photo tripod; JMI's wedge and tripod package; Tuthill's Isostatic Equatorial Mount; and a closeup view of JMI's innovative wedgepod.

Your Meade ETX

by Steve Edberg

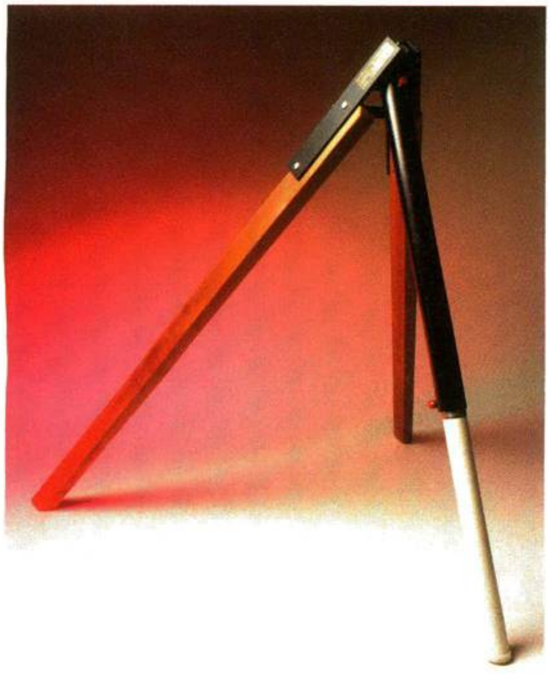
ferred) mounting holes. It also has adjustable rubber feet for use on a tabletop. The wedge has an indicator for latitudes from 20° to 57°, and can be used from about 19° to 58° (8½° south of the Arctic Circle, contrary to the ad statement). The prototype wedgepod is limited to about 20° to 50° latitude but JMI says they will expand this in the future.

When the ETX is equatorially mounted on a tripod or wedgepod, the center of gravity is not directly over the centerpost. One can see the opposing tripod leg vibrate. This offset was also present on my Bogen 3040 tripod (with head) as well, and the leveling of the wedge disappeared when the ETX was added to my Bogen+wedge.

The Tuthill Isostatic Equatorial Mount ($270 if purchased separately) is intended purely for astronomical use. I was initially skeptical about this unit because of the long legs but found some real advantages as I used it.

This tripod is short enough (45 inches) that grade school children can reach the eyepiece of the ETX, and adults won't have to bend down too far. It's great for use at star parties. The wide spread of the long legs also permits viewers to move easily in and out if they are queued up for a look-through. That wide spread is useful in another way: A chair conveniently fits between the legs and the instrument is at a reasonable height for observing while seated.

The Isostatic tripod doesn't fold down small. The redwood "azimuth" legs are one-piece, long (59 inches), and solid. They are held on the tripod with pivoting, black-anodized aluminum L-brackets. The "altitude" leg is made of aluminum with a sliding polyvinyl chloride (PVC) pipe nested inside and lockable with a thumbscrew. The aluminum pipe attaches to the dense plastic heart of the tripod with a thumbscrew too. Collapsing the



PHOTOGRAPHS BY JIM FORBES

Left to right: Tuthill's 6x30 right angle finder; JMI's ETX polar finder; and JMI's MAX computer for the ETX.

tripod means removing the altitude leg and folding together the azimuth legs, yielding two large pieces and some thumbscrews you should be careful not to misplace.

The telescope is held in place with another long thumbscrew. Holding the telescope while threading the thumbscrew through the heart and L-brackets is risky, though that's what one is forced to do. It appears that a simple modification would permit telescopes with differently sized mounting bolts to be attached to the tripod.

— Polar Alignment Accessories —

Once the ETX is equatorially mounted, it needs to be polar-aligned. Then the next order of business is finding objects for viewing. The compact design of the ETX makes seeing the pole through the finder a near impossibility. Finding objects at high declinations is challenging too.

Tuthill and JMI offer solutions. Tuthill's Precision Polar Axis Finder was reviewed by *Astronomy* (May 1991) and was found to provide good polar alignment.

The prototype of JMI's ETX Polar Finder ($49.95) was supplied with clear instructions for mounting. It is a 1x device consisting of a small-diameter sighting tube mounted on a hinged plate (so it folds out of the way for transport). I had no trouble seeing Polaris through the small tube and polar aligning for casual observing.

Two right-angle finders are now on the market, from JMI and Tuthill, that make finding easier. The JMI unit is actually a 90° finder conversion kit ($69). Clear instructions explain the disassembly of the Meade finder and the reassembly using a new tube + diagonal mirror assembly. Fits were tight, and be careful not to cross-thread the old parts onto the new. The correct-view 5x21 Meade finder becomes reversed; up/down is correct but right/left is reversed.

The new finder is low profile and is as elegant on the telescope as the original, but its use was not as pleasant. The mirror assembly interferes with the fork arm so that the celestial pole cannot be reached. Thus one is forced to use a separate polar axis alignment device or method, or file away plastic from the finder or fork arm to reach the pole.

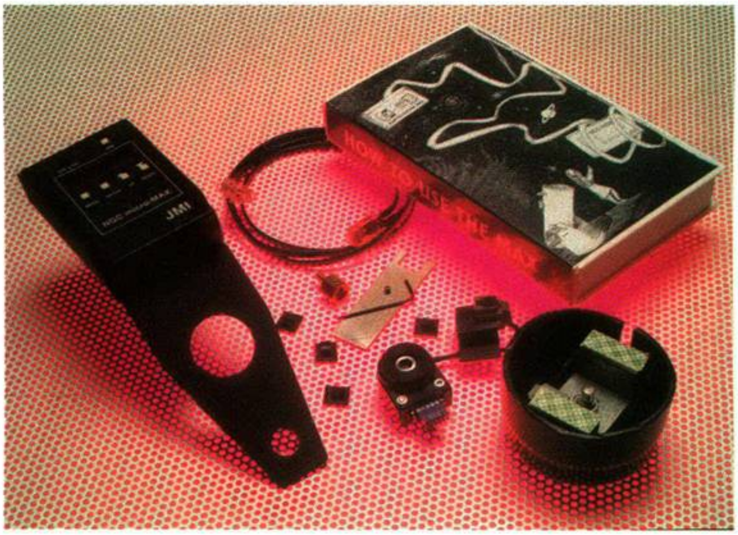
Because of the close quarters, in many telescope positions your nose or cheek is going to collide with the finder or the eyepiece when either is used. There is no provision for rotating the JMI finder's eyepiece out of the way to minimize this.

Tuthill offers a 6x30 right angle finder ($125). The finder's mount must be machined out to fit the new finder tube (Tuthill does this for you). It makes for a close fit between finder and mount so that little adjustment is possible (or necessary, fortunately) and any burrs left from the machining must be removed (a fingernail will suffice).

The Tuthill finder's eyepiece stands pretty tall, so cheek/nose interference could be a problem. However, by rotating the finder's prism assembly, it can be moved out of the way when the telescope is being used. The prism must be rotated slightly so the telescope can reach the celestial pole. The finder's eyepiece threading is so loose that it moves around, taking the crosshairs with it, and making precision pointing at high power impossible. A small piece of vinyl tape on the threads might minimize this problem.

Finding can be done with computers, nowadays, and JMI has extended its MAX series of computers to the ETX. Installation of the encoders is the same for all of the computers. The right ascension encoder instructions were good, though there was a difference between the illustration and the words describing cable placement. There was no problem installing it with the Tuthill power indicator light already in place. The cable connecting the encoder

Opposite page, left to right: Tuthill's piggyback camera mount for the ETX; JMI's upscale version.



KODAK 5
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(inside) to the socket (outside) is squeezed tightly by the base plate and could also be damaged when the telescope rests on it.

The declination encoder installation was a bit more difficult, with more differences between the illustration and the instructions. Still, the hardware installed easily. Do have some double-sided foam tape available — the encoder shaft was a bit long and the tape, placed on the feet of the encoder support, served as a spacer. You will also need the tape to better attach the hook and loop material on the supplied vinyl cover. Follow the instructions carefully to set up the MAX for use on the sky. The supplied videotape was moderately helpful, with some useful general hints as well as specific examples.

When I set up the MAX to use it, I had trouble getting the position error indication below 2.5° on one occasion. I did manage 0.2°, and the instructions say the error should not exceed 0.5°. The instructions note that the error could be due to the mount's axes not being square. JMI's owner, Jim Burr, mentioned that placing a piece of tape over the right ascension encoder bolt might reduce the error and JMI may include that in future shipments. Also, one must use a sturdy tripod or pier. Otherwise flexure can lead to large error indications.

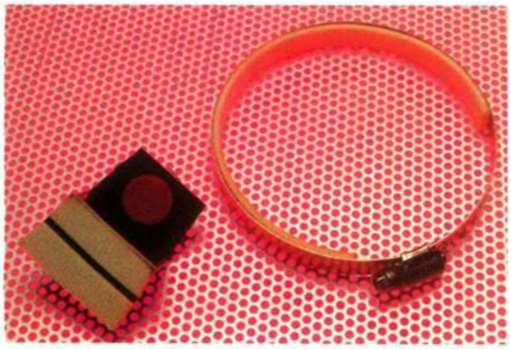
I had an unexpected problem as well. On a humid (but not dewy) night I set up the NGC-microMAX for use. In a little while, it started indicating occasional errors, and then showed them continuously. I suspect the electronics didn't work well in the humidity, though JMI says they have never received similar reports.

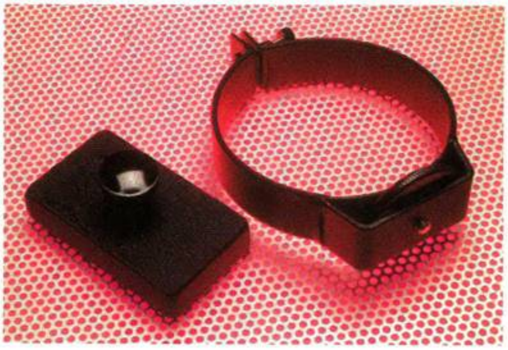
It doesn't look like this computer will work with my ETX. With numerous alignment attempts I managed to find my target in the eyepiece only once, and that was near one of my alignment stars and with a larger-than-desirable error message. If you get one, be sure the computer will work with your telescope, stand, and observing conditions.

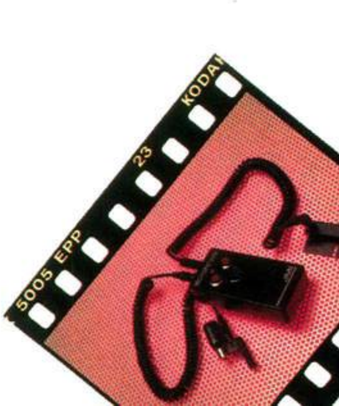
— Piggyback Camera Mounts —

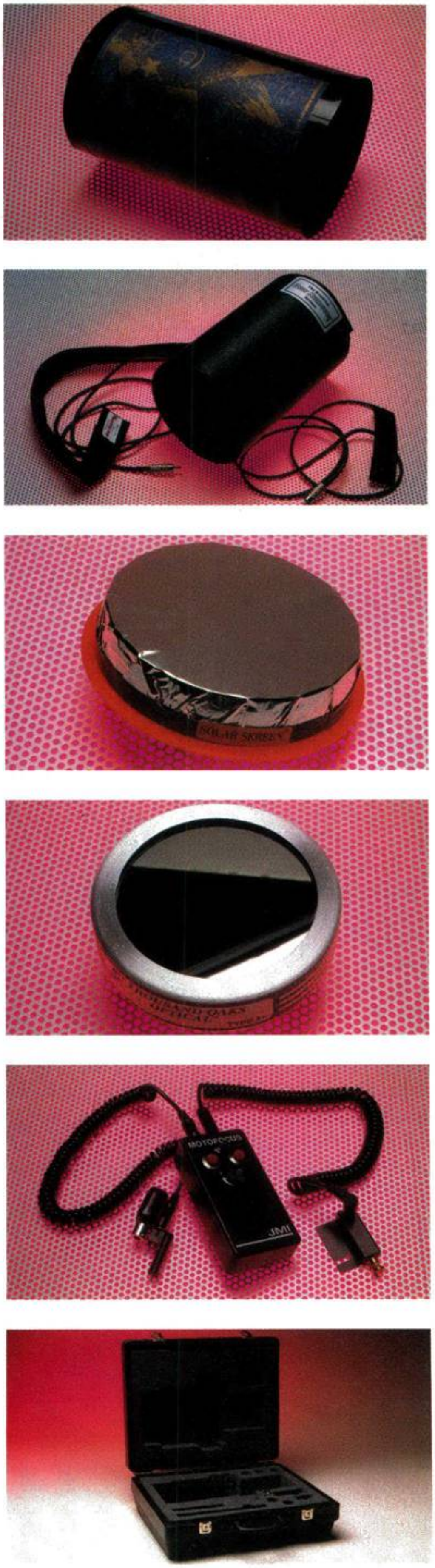
A telescope as easy to use as the ETX just begs for a camera mount. Tuthill and JMI both offer one. The Tuthill unit ($48) uses a hose clamp to hold a Z-shaped (90° angles) aluminum piece (with ¼-20 camera bolt) on the tube of the ETX. The base of the aluminum piece is not contoured to match the ETX tube. All the parts in contact with the tube are covered with a liner to protect the tube's finish. Flexure is a real possibility with this approach.

In contrast, the JMI camera mount ($59.95) is very elegant. It is a low profile, rubber coated single piece. A large-diameter thumbscrew holds the camera in place. A notable addition is the counterweight supplied to balance the camera on the telescope.









Top to bottom: Tuthill's No Du cap; the Kendrick Dew Remover; Tuthill's Solar Skreen sun filter for the ETX; the Thousand Oaks Type 2+ filter; JMI's Motofocus accessory; and JMI's foam-lined carrying case.

Dew Prevention and Stray Light Reduction

Humid climates require an additional accessory, one that will prevent, or at least slow, the condensation of dew on the corrector lens of the telescope. Most observers also like to reduce stray light entering the telescope. Both of these requirements can be met with a dew cap. The dew cap is an open-ended cylinder that slips over the front of the telescope. Its length usually exceeds the aperture of the instrument.

Tuthill and Jim Kendrick Studio, Inc. offer dew caps. The Tuthill No Du cap ($56) uses the simple design, and its length is about the same as the ETX's tube length. It has a black felt inner lining that is very effective in trapping stray light and a pleasing, astronomically themed outer cover. The dew cap slips tightly over the corrector lens cell of the ETX. It's too bad that it doesn't slide completely onto the tube, so that it could be carried easily as part of the telescope.

The Kendrick Dew Remover for the ETX (Controller, $65 + 4-inch heater, $40) is an extension of his widely acclaimed line of dew removers. A flat, felt-lined dew cap rolls to fit around the circumference of the telescope tube. Nicely packaged heater tape can first be attached around the sky-end of the telescope with hook and loop material and then the dew cap is added. Another, lower-priced option has just become available. At press time, Clear Night Products has just introduced the TeleWrap/Dew Cap, which retails for $21.95. It is custom made for the ETX. It appears to be a viable, low-priced alternative.

Solar Filters

An astronomer can double the amount of observing time available by adding the sun to his or her observing list. Tuthill and Thousand Oaks Optical offer safe solar filters suitable for observing sunspots and faculae (bright areas) on the sun's bright photosphere. Both manufacturers supply instructions on the safety and maintenance of their solar filters.

The Tuthill filter ($48) uses his patented Solar Skreen aluminized mylar mounted on a soft plastic cell. The filter can be securely attached to the sky-end of the telescope by squeezing it on. A cool blue image appears in the eyepiece but I noticed a rather bright sky — probably the result of sunlight being scattered by the filter into the telescope. This is not dangerous, only distracting.

The Thousand Oaks Type 2+ filter ($79) is deposited on a glass base and is mounted in a metal cell. It presents an orangish image of the sun. A single pinhole in the coating needed to be opaqued (a black permanent marker works, as noted in the instructions) and internal reflections were easily eliminated with a slight tilt of the filter cell on the telescope.

— Miscellaneous Accessories —

A variety of other aids for the observer is available from Tuthill and JMI. If you purchase the ETX from Tuthill he includes his Power Saver Red LED Indicator Light for the drive. Otherwise, he will install it in yours for $50. A small hole is drilled in the base of the telescope and two leads are soldered to the electronics assembly inside the base.

Vibrations induced during focusing or when making declination corrections with the slow motion knob can be a problem with the ETX. JMI has long offered focuser and declination motors and they have extended the line to the ETX. Their Motofocus lists for $99.95 and the Motodec lists for $99.95; purchased together the price is $169.90 (but includes only one dual hand control unit with a switch and wiring to operate both systems one at a time). I like both accessories.

The Motodec does a good job moving the telescope in slow motion. It is a small assembly with a strong motor that fits on the far side of the fork arm with the declination knob. The coiled cord plugs into the motor unit and into the hand control when in use. Extra O-rings are supplied (and it is praiseworthy that JMI supplies extras of other small parts, such as set-screws, as a convenience to their customers). The installation instructions were marvelously easy to follow.

The installation instructions for the Motofocus were also good, but must be followed carefully. A similar coiled cord runs between the motor and the hand controller. The plug's insulation was shaved so it could fit into the motor assembly. In place, the plug interferes with reaching the celestial pole. Also, the motor came loose from its connector to the focus assembly once when I was trying to remove the plug. Apparently it is press-fit on.

A speed control is included on the hand unit but the motor won't start at low speed settings. It is fine at high speeds, but this may be too fast for some observers to bring the telescope to focus.

Tuthill offers the "ETX How to Use Video Tape" for $29. It begins by assuming that you have read the Meade instruction manual (something I strongly advise) and offers some useful tricks and suggests modifications for an ETX observer. It is mainly a product listing and demonstration.

JMI offers a foam-lined carrying case for the ETX ($109.95). It is die-cut to fit the telescope (with MAX encoders), its original accessories, a few extra eyepieces, and some JMI accessories such as the MAX computer. There isn't much room for additional accessories. It has a good hinge and the handle looks sturdy enough. The weight is not centered under the handle when it is loaded, unfortunately, and there's no shoulder strap.

Meade ETX Accessory Providers

Jim's Mobile, Inc.
810 Quail St. Unit E
Lakewood, CO 80215

Jim Kendrick Studio, Inc.
2775 Dundas Street West
Toronto, Ontario M6P 1Y4
Canada

Roger W. Tuthill, Inc.
Box 1086Q
11 Tanglewood Lane
Mountainside, NJ 07092-0086

Thousand Oaks Optical
Box 4813
Thousand Oaks, CA 91359

Clear Night Products
Box 721480
Berkley, MI 48072

Meade Instruments Corporation
6001 Oak Canyon
Irvine, CA 92620

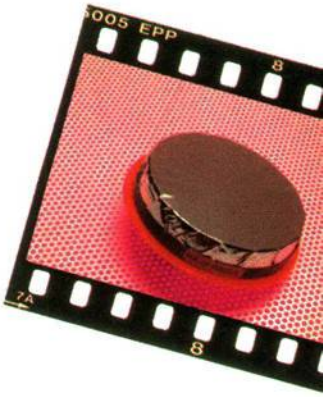
Roger W. Tuthill, Inc. sells the ETX scope and will package-price, with significant discounts, his accessories when purchased at the same time as a telescope. The prices quoted in this article are for separate, individual purchases.

Meade itself sells an array of basic accessories for the ETX including eyepieces, filters, tripod legs, and a carrying bag.

The Meade ETX telescope has spawned a number of accessories from a variety of manufacturers. Not all of those offered have been discussed here. Meade itself offers standard accessories like eyepieces, Barlow lenses, a T-adapter, an erecting prism, high-latitude trpiod legs, and a carrying bag. Careful shopping will present a selection of accessories that will make the ETX an even better telescope for astronomers.

Steve Edberg is a gadgeteer and avid amateur astronomer living in La Canada, California.

KODAK 5005 EPP



5005 EPP
17A

Gemini, Lynx & Canis Minor

Artwork at left originally published in *The Glorious Constellations*, © 1991 Harry N. Abrams, Inc.

Don your warm woolies, the deep-sky splendors of the winter Milky Way await.

by Tom Polakis

THE BRIGHT WINTER constellations ride high in the February sky for observers at northern latitudes. Gemini the Twins is a Milky Way constellation filled with clusters and nebulae. North of Gemini is Lynx the Bobcat while diminutive Canis Minor the Small Dog lies to the south.

Our first stop, the open cluster **M35** (NGC 2168), is some 2,800 light-years away. This spectacular cluster holds dozens of stars brighter than 10th magnitude, most in the central 20' where the field is peppered with more than 150 stars. A few stragglers extend to 1°. A string of brighter stars toward the center is easily identified by its saxophone-like shape roughly 10' long.

Careful observers will find a hazy object in the same low-power field with M35, the fainter open cluster **NGC 2158**. A 14-inch scope at 500x may resolve 30 stars against a fairly uniform background, while a 20-inch scope will double that number.

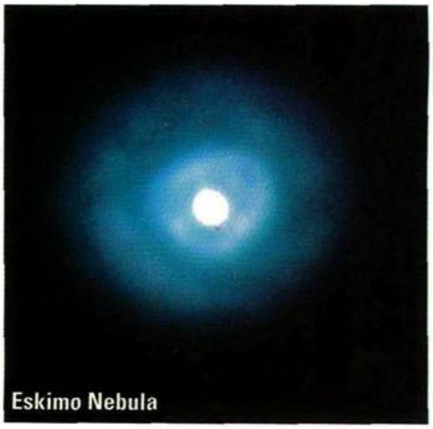
The tiny planetary nebula **J900** is roughly 3° northwest of 2nd-magnitude Gamma (γ) Geminorum. It was discovered in 1916 by the French double star observer Robert Jonckheere and is found in small instruments by "blinking" the field with a nebula filter. Move the filter between your eye and the eyepiece. J900 should leap into view as the one "star" that does not dim with the filter in place. Use the highest magnifications seeing will permit to resolve its 8" disk.

You'll have no problem locating our next target, **Procyon** (Alpha [α] Canis Minoris). It is the eighth brightest star in the sky and a challenging binary. The two stars are separated by 4.7", but Procyon B is 7,000 times fainter than Procyon A, which makes separating the two difficult. Procyon B is in a position angle of 70° (east-northeast) to its magnitude 0 neighbor. The system is 11.4 light-years away and completes one revolution in 40.65 years.

The **Medusa Nebula** (Abell 21) is the 12th largest planetary nebula — on a realistic list of observable planetaries, its apparent size is exceeded only by the Helix Nebula. At a distance of 2,000 light-years, its angular size corresponds to true dimensions of 4 by 3 light-years. Don't be fooled by the Medusa's 10.3 magnitude. Its surface

NGC 2419

Preston Scott Justis



Eskimo Nebula

Jack Newton

brightness is quite low. UHC and OIII filters improve the view.

To add to the variety of planetary nebulae in Gemini, try spotting NGC 2392 — dubbed the **Eskimo Nebula** by astronomer Rudolph Minkowski. This elliptical object appears nearly pole-on and lies 4,600 light-years away.

The Eskimo's disk appears bluish and divided into two concentric shells. The inner portion is bright, round, and mottled. Separating the inner disk from a fainter outer shell is a dark ring. The shell fades outward before ending abruptly. All of this detail surrounds a 10th-magnitude central star.

Little more than 2° east of the Eskimo Nebula is the open cluster **NGC 2420**. In an 8-inch telescope, the cluster yields 30 stars, most of which glow at 12th and 13th magnitude. A brighter star appears on the cluster's western edge. NGC 2420 sits some 6,700 light-years away.

A line from Castor projected through Pollux points to the interesting cataclysmic variable star **U Geminorum**. You will most likely see this star in its normal 14th-magnitude state. Every four months, it brightens dramatically to become a 9th-magnitude binocular object. These episodes last only a week or two. The next event should occur sometime in mid-March.

Castor (Alpha Geminorum) is a favorite, resolvable, naked-eye star that is a telescopic double. During the past decade, the separation of its two stars has increased from 3" to 4" — the pair will continue to widen in coming years. A full orbit of the binary system takes more than 500 years.

Most telescopes will split Castor A and B on a steady night. The relative brightness of each star makes it difficult to see them separately. Glare from the stars can be cut with an aperture stop or a filter to provide a better view.

NGC 2683

Jason Ware

M35 and NGC 2158

Jerry Lodriguss

Use your unaided eyes to compare the color of Castor (a pair of bluish type A stars) to yellowish Pollux (type K).

Forming a tight triangle with Castor and Pollux is **NGC 2371-2,** a planetary nebula 5,000 light-years away. A 13-inch scope brings out the two lobes of this bright object, each measuring roughly 20" across. They straddle the northeast and southwest sides of the central star. The southwestern lobe appears brighter and larger with a more pronounced center. Long exposure photographs also show two very faint, extended wings to the northwest and southeast, bringing the nebula's size to 3'. Such faint features eluded my 20-inch telescope. A better size estimate is roughly 1'.

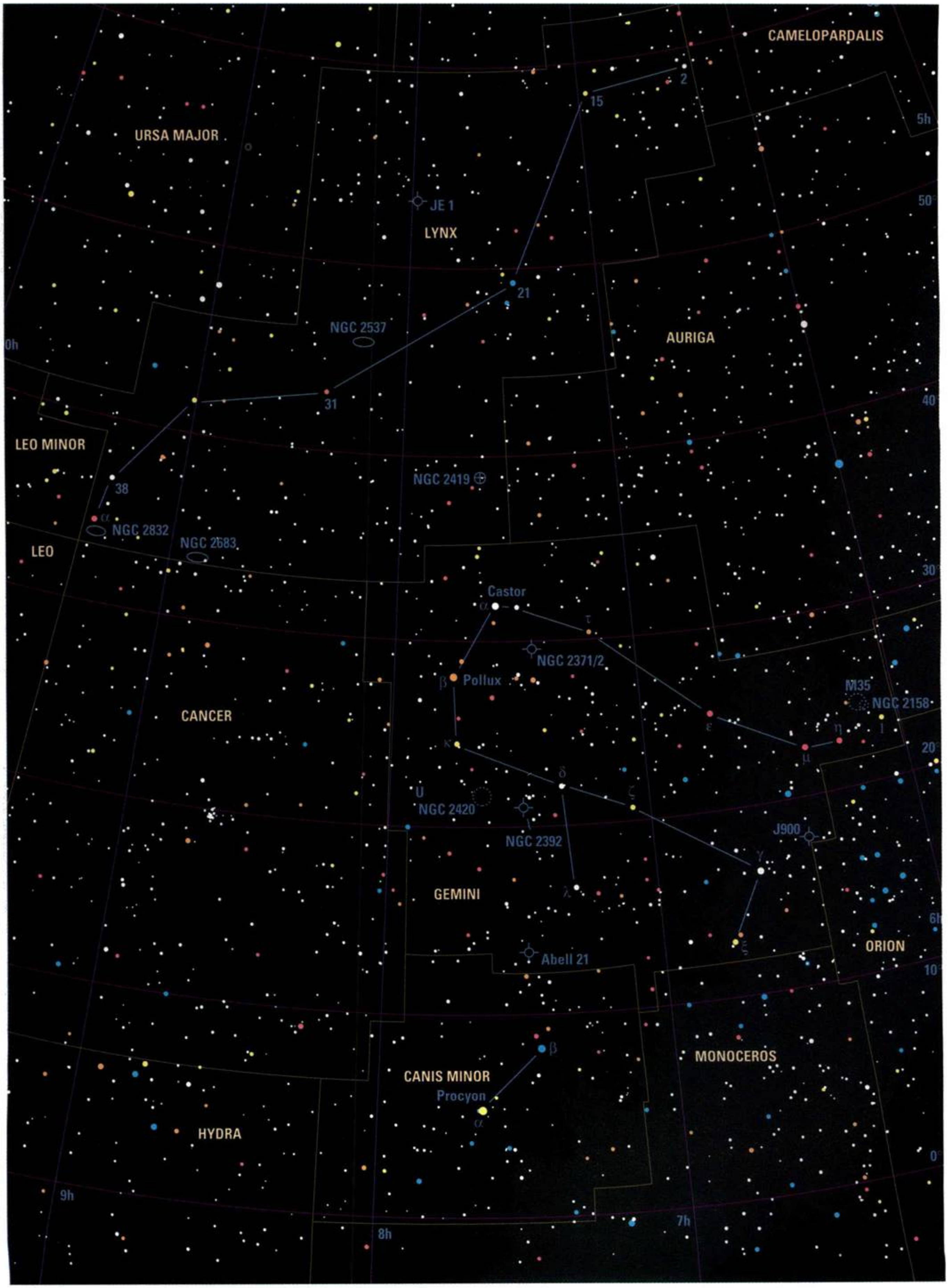
NGC 2419, aptly named the Intergalactic Wanderer, is one of the most distant non-galaxy objects visible. Located in the constellation Lynx, this globular cluster is 260,000 light-years away — nearly twice as far as the Magellanic Clouds, the Milky Way's satellite galaxies. Its great distance fools viewers into thinking it's insignificant. In fact, NGC 2419 is one of the five most luminous clusters in our galaxy. If it were at the same distance as M13, it would shine brighter than 6th magnitude.

NGC 2419 is not easily resolved — its brightest stars have a magnitude of only 17.5. Using his 18.7-inch telescope, William Herschel called it a bright nebula. When Lord Rosse's observed it with a 72-inch telescope he suspected it was a globular cluster. Amateurs have had similar difficulty in their attempts to resolve the cluster's faint stars. NGC 2419 is easily visible in my 8-inch scope as a faint haze 2' across, but seems nothing more than "clumpy" when viewed through a 20-inch.

More than 3 light-years in diameter, **JE 1** is a large planetary nebulae discovered by R. Jones and R. Emberson in 1939. JE 1 is plotted, but not labeled, on Wil Tirion's *Sky Atlas 2000.0*. It's not often that amateur astronomers can observe a planetary nebula discovered this century: They can with JE 1. In a 16-inch scope with an OIII filter, its faint 5' disk appears to have bright nodules on the northwestern and southeastern edges. Even an 8-inch scope with the same filter at a dark site brings out

NGC 2158

Martin Germano


CAMELOPARDALIS
2
15
5h
URSA MAJOR
JE 1
50°
LYNX
21
NGC 2537
AURIGA
0h
31
40°
LEO MINOR
NGC 2419
38
α
NGC 2832
NGC 2683
LEO
30°
Castor
α
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NGC 2371/2
β
Pollux
M35
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NGC 2392
J900
γ
GEMINI
λ
6h
ξ
ORION
Abell 21
10°
MONOCEROS
β
CANIS MINOR
Procyon
α
HYDRA
0°
9h
7h
8h

the bright lobes. Use a magnification of 100x or less to increase your chance of spotting it.

Veteran deep-sky observers will say the **Bear Paw Galaxy** (NGC 2537) does not look the way a galaxy is supposed to look. Through an average-size telescope, it exhibits a sharp-edged disk that resembles a planetary nebula. It appears even stranger in larger scopes.

At a distance of only 22 million light-years, the Bear Paw is a rare, nearby example of a blue compact dwarf galaxy. These galaxies have very low luminosities and spectra similar to HII regions. They also hold a large population of young O and B stars.

NGC 2683 is another nearby galaxy and a showpiece object in any telescope. It is often neglected in favor of the Milky Way gems available to the south. NGC 2683 is similar to the Milky Way in luminosity and has an inferred population of more than 300 globular clusters, which is more than the Milky Way.

Less than 1° south of 3rd-magnitude Alpha Lyncis is **NGC 2832** and its associated galaxy cluster, **Abell 779**. The rather sparse cluster lies about 300 million light-years away. Elliptical NGC 2832 is an elongated halo with a brighter center. A tiny elliptical, **NGC 2831**, seems to touch NGC 2832 on the western side. A 1° field around NGC 2832 holds very faint members of Abell 779. These galaxies are often seen as clumps that are barely visible above the bright background sky. A 10-inch telescope will show as many as a half dozen companion galaxies.

Tom Polakis is an aerospace engineer living in Arizona. His primary astronomical interests are deep-sky observing and photography.

The Twins

> *"For fate has wove the thread of life with pain,*
> *And twins ev'n from the birth are misery and man!"*
> The Odyssey of Homer, *Book VII*
> *—Alexander Pope (1688–1744)*

The Dioscuri (sons of Zeus), Castor and Polydeuces (Pollux in Latin), are famous throughout Greek mythology. Castor was known for his horsemanship, while Polydeuces was a famed boxer. The two were inseparable; even death could not part them. When Castor died in battle, Zeus brought Polydeuces (an immortal) to Mount Olympus. The son pleaded with his father to let Castor share his immortality. Zeus granted the wish and on alternate days the brothers lived in the underworld and with the gods.

To the Native American Klamath tribes of the Pacific Northwest, the stars Castor and Pollux also denoted twins. They believed the twins' icy stares caused the lakes to freeze in December.

In 5000 B.C., the vernal equinox occurred in Gemini. This gave the constellation great importance to burgeoning agricultural societies. The constellations Taurus and Aries also played a part. The sun moves through Aries and then Taurus on its way to Gemini. It told the farmers that spring was on its way. First the lambs, then calves, then kids were born. Ancient texts depict Gemini as a pair of young goats. —*Andrea Gianopoulos*

Deep-Sky Objects in Gemini, Lynx and Canis Minor

Object	R.A. (2000.0)	Dec.	Mag.	Size/Sep./Per.	Type	Notes
NGC 2158	6h07.5m	24°06'	8.6	5'	OC	—
M35	6h08.9m	24°20'	5.1	28'	OC	200 stars
J900	6h25.9m	17°47'	11.7	8"	PN	—
NGC 2371/2	7h25.6m	29°29'	11.3	55"	PN	—
Abell 21	7h29.0m	13°15'	10.3	615"	PN	Medusa Nebula
NGC 2392	7h29.2m	20°55'	9.2	15"	PN	Eskimo Nebula
Castor	7h34.6m	31°53'	1.9,2.9	3.9"	Dbl	—
NGC 2419	7h38.1m	38°53'	10.3	4.1'	GC	"Intergalactic Wanderer"
NGC 2420	7h38.5m	21°34'	8.3	10'	OC	100 stars
Procyon	7h39.3m	05°14'	0.4,10.0	4.8"	Dbl	—
U Gem	7h55.1m	22°00'	8.2-14.9	120	VS	Dwarf nova
JE 1	7h57.8m	53°25'	12.1	399"	PN	—
NGC 2537	8h13.2m	46°00'	11.7	1.6' by 1.4'	Gal	SB(s)m
NGC 2683	8h52.7m	33°25'	9.8	8.4' by 2.4'	Gal	SA(rs)b
NGC 2832	9h19.9m	33°44'	11.9	3.0' by 2.1'	Gal	E2, in Abell 779

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep./ Per.:** Size in arcminutes or arcseconds, separation in arcseconds, or period in days. **Notes:** Hubble type for galaxies or type for variable stars.

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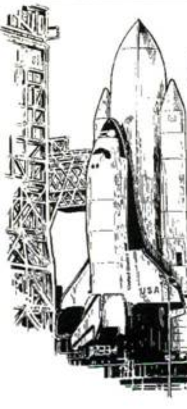

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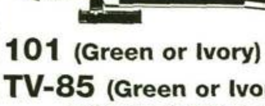

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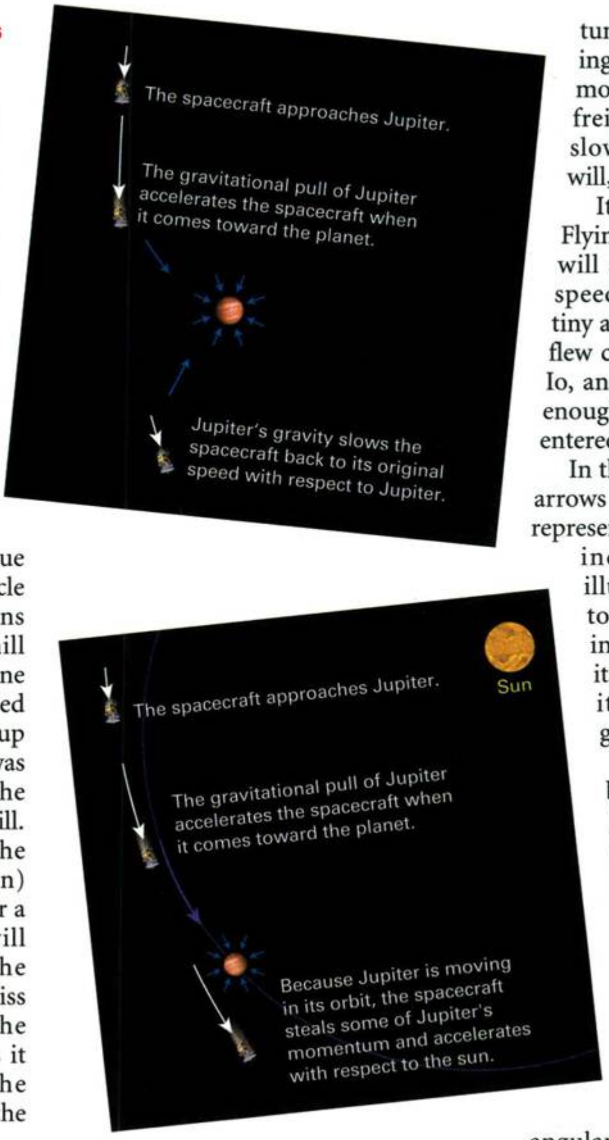
Gravity Assists, The Moon's Name, 1999 Comets

Q: When a spacecraft flies by a planet to receive a gravity assist, why does it gain momentum by using a planet's gravity while approaching but not lose that gained momentum when it recedes from the planet? How does this "slingshot effect" work to increase the velocity of the spacecraft? — *Khalid Omar O. Al-Majid, Dubai, United Arab Emirates, and nine others*

A: This is an excellent question that I wondered about myself when I first heard about the technique called "gravity assist." I used to bicycle to work when I lived in the canyons above JPL. When I coasted downhill toward the creek at the bottom of one canyon, my speed of course increased nicely. But the road inevitably rose up again and out of the canyon, and I was soon pedaling hard to overcome the same gravity that assisted me downhill.

Well, this is also true (minus the bicycle's air resistance and friction) when a spacecraft flies by a planet for a "gravity assist." The spacecraft will accelerate as it falls in toward the planet. If its path is designed to miss the planet rather than impact, the spacecraft will slow down again as it recedes, eventually losing all the momentum gained with respect to the planet. So what good is that?

The key is that phrase "with respect to the planet." With respect to the sun, it's an entirely different matter. Let's look at Pioneer 10 and 11, Voyager 1 and 2, and Ulysses — all of which flew by Jupiter and received a gravity assist. Cassini will do the same en route to Saturn. Since all masses attract one another gravitationally, Jupiter attracts the spacecraft, but the spacecraft also attracts Jupiter. So, if you fly your spacecraft *behind* the planet in its solar orbit, the spacecraft will pull back on Jupiter and remove some of Jupiter's orbital energy — its angular momentum about the sun —while gaining that energy for itself. It's like a mosquito getting hit by a speeding freight train. The mosquito will slow the train ever so little, but will, as a result, be accelerated.


The spacecraft approaches Jupiter.
The gravitational pull of Jupiter accelerates the spacecraft when it comes toward the planet.
Jupiter's gravity slows the spacecraft back to its original speed with respect to Jupiter.
The spacecraft approaches Jupiter.
Sun
The gravitational pull of Jupiter accelerates the spacecraft when it comes toward the planet.
Because Jupiter is moving in its orbit, the spacecraft steals some of Jupiter's momentum and accelerates with respect to the sun.

Jupiter can give spacecraft a gravity assist. At the top, a spacecraft passes an imaginary stationary Jupiter. At the bottom, the real, moving Jupiter gives the spacecraft an added boost in the sun's reference frame. The blue arrows indicate gravity. *Astronomy:* Elisabeth Rowan

It can work the other way, too. Flying in front of an orbiting body will slow down a spacecraft (as it speeds up the orbiting body by a tiny amount). The Galileo spacecraft flew close in front of Jupiter's moon Io, and the trade-off slowed Galileo enough to save some propellant as it entered jovian orbit.

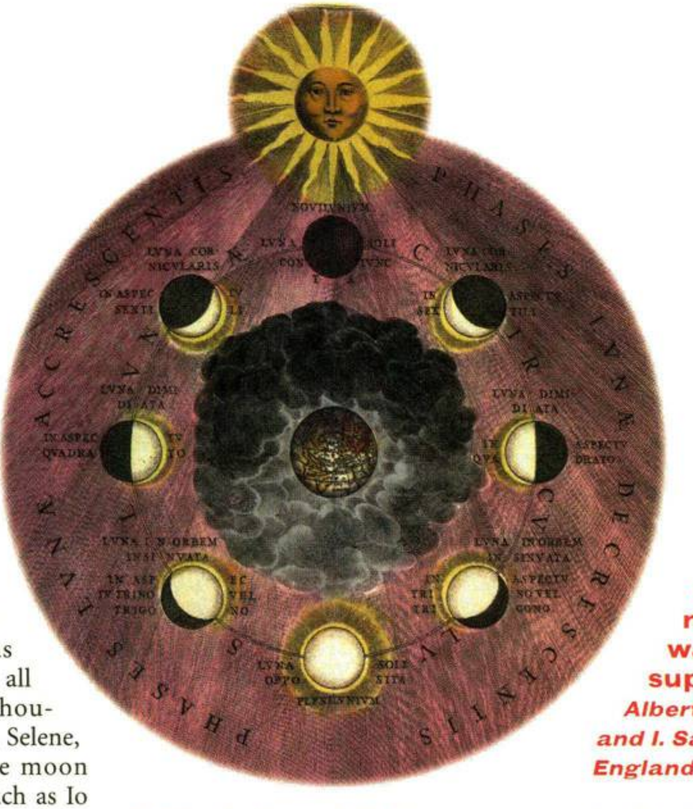
In the illustrations at left, the white arrows indicate velocity: Their lengths represent relative speeds, and they also indicate direction. In the top illustration, a spacecraft falls in toward Jupiter, and its velocity increases (and bends). But then its speed drops off again to what it was at first, relative to the giant planet.

The bottom illustration brings the sun into the picture. Jupiter has orbital motion around the sun, shown by the purple line. Leaving Jupiter, the spacecraft has *added* some of Jupiter's orbital energy to itself, which it will never lose.

To be clearer, it's really an "angular momentum" assist. Gravity only serves to connect the spacecraft temporarily to the source of angular momentum. — *Dave Doody, Jet Propulsion Laboratory*

Q: Why doesn't our moon have a name, like Io or Triton? — *Dave Anderson, Evanston, Wyoming; and Michelle Klippert, Idaho Falls, Idaho*

A: The moon does, of course, have a name: the moon. It was for a long time the one and only moon. When other planets were found to have similar companions, they were referred to also as "moons," just as stars are sometimes referred to as "suns" and planets as "worlds." The moon is one of the things that has been known to all peoples in all times; therefore it has had thousands of names, such as Luna, Selene, der Mond, and la Lune. The moon doesn't have a Greek name such as Io and Triton because it predated the mythologies that gave rise to such names — or rather, it was itself the inspiration of such mythologies. Of course many individual features on the moon do have names (see "Naming the Man on the Moon," page 82). — *William Sheehan*



Earth's sole natural satellite has a name: the moon.

Q: Are any comets due to return to the inner solar system in 1999? — *Duke Desabrais, Ottawa, Ontario*

A: Really bright, notable comets such as Hyakutake in 1996 and Hale-Bopp in 1997 are usually making one of their first passes through the inner solar system. These long-period comets haven't graced terrestrial skies for thousands, if not millions, of years, loping around the sun in incredibly long cigar-shaped orbits. We don't know when the next long-period comet will sweep through our neighborhood, but one thing is certain: As you read this, many are on their way in from the outer solar system and are just waiting to be discovered.

If you're willing to go after telescopic targets, at least one comet ought to be visible at any given time through a mid-sized telescope (in the 10-inch range) under a dark sky away from city lights. And in most years, at least one comet grows bright enough to be seen with binoculars.

What's in store for 1999? So far, according to predictions, two short-period comets should be visible in 6- to 8-inch telescopes, two should lurk in the larger-aperture, 10- to 12-inch range, and one ought to shine bright enough for binocular observers.

The latter is P1998 M6, or Comet Montani. It starts the year low in the west after sunset, glowing at magnitude 5.2, an easy catch provided you have a flat, unobstructed horizon. Look early in the year, for by March and April, Montani will be both lower and fainter.

For moderate-sized telescopes, there's Comet Tempel 2, which reaches peak brightness, magnitude 9, in mid-August among the stars of Scutum. The other target, Comet Machholz 2, crests at magnitude 8 during November and December.

Finally, for the not-so-faint-of-heart there are Comets Schuster and Forbes. They only manage a feeble light of magnitude 13, a brightness that's only attainable in 10-inch scopes or larger. Comet Forbes peaks during July and August, while Comet Schuster weighs-in during November and December.

Happy hunting! — *John Shibley*

Q: As our sun becomes a red giant, is there a chance that some of our solar system's outer planets or moons may at some point warm up enough to support life? — *Bill Albertson, Chelsea, Michigan; and I. Satterley, Bedfordshire, England*

A: Possibly. Mercury will almost certainly be vaporized as the sun brightens in its red giant state six billion years from now. Though life on Earth will have been extinguished, scientists have shown that Earth itself may escape destruction by spiraling away as the sun sheds its outer atmosphere into space. If the sun loses enough mass, even Venus might escape. The outer planets and their satellites, however, may become more benign.

In a recent research paper, planetary scientists Ralph Lorenz, Jonathan Lunine, and Christopher McKay suggest that Saturn's large moon Titan, which has a thick atmosphere, may develop a relatively warm water-ammonia ocean that could last long enough for life to develop. We'll just have to wait and see. — *James Kaler, University of Illinois*

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to every question or respond to each one individually.

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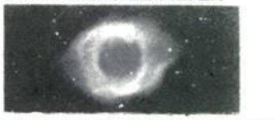

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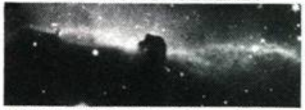

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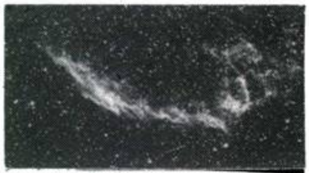

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*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

Premium*
LUMICON Multiple Filter Selector, holds 5 1¼" filters .... **$129; $99** if ordered w/filter
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces.................. **$99.50**
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS.................. **$199.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography.............. **$199.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)..... **$399.50**
2" Rear Cell Filter, fits SCT's .... Deep-Sky, **$199.50** UHC, O-III, H-Beta, **$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces.................. **$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces.............. **$199.50**
Choice of ***any two*** LUMICON filters (**Save 7%**) .... 1¼" **$185.00**; 48mm **$370.00**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"**.......... **$99.50, 48mm**.......... **$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines.................. **1¼" $99.50; 48mm $199.50**
LUMICON Comet (Swan band) Filter .... **1¼" $99.50; 48mm $199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm.............. **$7.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece.......... **$19.50**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece............ **$25.00**
**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

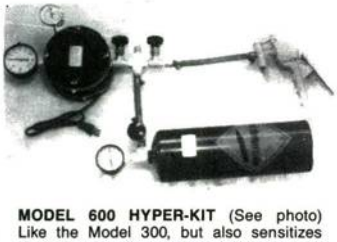
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$189.50**
48mm Coma corrector/field flattener .. **$285**
3X Relay Diagonal (see photo) **$99.50**
Illuminated reticle eyepiece, pulsed . **$119.50**
Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$299,** Mamiya 645 **$98**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) .... **add $179.50**
Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $139;** Pentax 645 **add $159**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** .... **$119.50** Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.
2. **Cable release** for long exposures . **$9.95**
3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left) .
6. **LUMICON 48mm DEEP-SKY FILTER $199.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM

HYPERED FILM IS 2-10X FASTER!

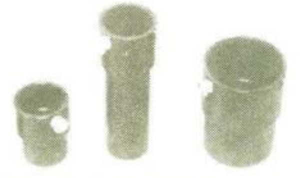
LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
Kodak PPF-400, THE BEST!	36	**$14.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	24	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$8.50**

LUMICON® ACCESSORIES   MEADE® TELESCOPES

TOLL-FREE ORDER LINE 1-800-767-9576   EXPERT INFORMATION 1-925-447-9570   FAX 1-925-447-9589
LUMICON, 2111 Research Drive, Suites 4-5, Livermore, CA 94550   OPEN M-F 9-5, SAT 9-1 PST

LOTS OF ADAPTERS



2" adapter for C-8, Meade 2080, etc.	$29.50
2" adapter for C-80, C-100 refractor	$39.50
2" adapter for C-70, C-80F, C-100F fluorite	$39.50
2" adapter for C-6, Comet Catcher, Meade 312	$30.00

EXTENSION TUBES

1" long 1¼" OD thread-in extension	12.00
2½" long extension (holds 1¼" filters)	19.50
4½" long extension for 1¼" eyepieces	$29.00
3" long extension for 2" eyepieces*	$29.00
2" long extension for 2" eyepieces*	$29.00

VIEWING ADAPTERS

2"/1¼" reducing bushing, threaded 48mm*	$25.00
2"/T-thread adapter, threaded 48mm*	$25.00
T-thread/1¼" adapter	$25.00
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	$59.50
Low profile star diagonal eyepiece holder	$16.00
Meade 2" Diagonal/Giant Easy-Guider	$39.50

**Threaded to hold 48mm filters.*

LED FLASHLIGHT . $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. Uses 2 AA cells (incl.) which last 60-100 hours.

LUMILITE red LED flashlight	$14.95
STARLITE™ adj. red LED flashlight	$24.95

RICH FIELD! 2° in 8" SCT

NOW ONLY
$99.95

LUMICON Rich-Field Viewer on C-8 with LUMICON 2" star diagonal and 2" eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2" or 1¼" eyepieces.

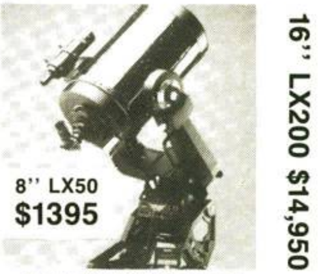
LUMICON Rich-Field Viewer (5-8")	$99.95
Giant Rich-Field Viewer (10-14")	$250.00

PENTAX 65° XL EYEPIECES

AMAZING performance! **All have** 20mm eye relief, adjustable eye guard, super multicoatings.

5.2mm F.L., 65° Apparent Field 1¼"	$279
7mm F.L., 65° Apparent Field 1¼"	$279
10.5mm F.L., 65° Apparent Field 1¼"	$269
14mm F.L., 65° Apparent Field 1¼"	$269
21mm F.L., 65° Apparent Field 1¼"	$269
28mm F.L., 55° Apparent Field 1¼"	$259
40mm F.L., 65° Apparent Field 2"	$299

MEADE 7" - 16" LX200
NEW! 7" - 10" LX50



16" LX200 $14,950

8" LX50
$1395

Meade 8" LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5" f/14 ETX Maksutov ($20)	$595
ETX, showroom price *(no 8 month wait)*	$649
8" LX10 w/wedge, hand controller ($65)	$995
Field Tripod for 8" LX10 ($20 P&S)	$195
8" LX50 w/wedge ($115 P&S)	$1395
Adj. tripod for 8-10" SCT ($30 P&S)	$295
8" LX200 w/computer ($65 P&S)	$2795
Wedge for photographing w/8" LX200	$139
7" LX50 f/15 Maksutov w/wedge ($125 P&S)	$1795
10" LX50, f/10 w/wedge, dec. motor, hand controller ($155 P&S)	$1695
10" LX200 w/computer ($155 P&S)	$3195
12" LX200 (f/10 only)($215 P&S)	$4495
Super Wedge for photogr. w/10",12" LX200	$395
16" LX200 f/10 w/tripod ($385 P&S)	$14,950
Dew Shields: 8" .... $119; 10"	$129
12" .... $189; 16"	$289

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4"—8", f/6 or f/10	$249
Giant EASY-GUIDER for 10"/12" f/4-f/10	$395

MEADE STARFINDERS

8" f/6
$749

New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6" f/8 Dobsonian Starfinder ($46 P&S)	$349
6" f/8 Equat. Starfinder 6(add $79 P&S)	$649
8" f/6 Dobsonian Starfinder (add $59 P&S)	$449
8" f/6 Equat. Starfinder 8 (add $89 P&S)	$749
10" f/4.5 Dobsonian Starfinder ($85 P&S)	$599
10" f/4.5 Equat. Starfinder 10 (add $99 P&S)	$879
12.5" f/4.8 Dobsonian Starfinder ($95 P&S)	$895
16" f/4.5 Dobsonian Starfinder (freight COD)	$1195
16" f/4.5 Starfinder 16 (ship. freight COD)	$2695

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

Magellan computer; specify Dob. or Eq. ($15 ship)	$295
LUMICON 1¼" UHC or O-III Filter	$99.50

Vinyl covers to keep dust-free (2 req.) for 6" - **$10**; for 8" - **$15**; for 10" - **$20**; for 16" - **$35**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

Over 3600 objects! — Also includes planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port

NGC-Sky Vector
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16" Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2" EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8".

LUMICON 48mm Coma Corrector/Field Flattener Lens	$285.00
LUMICON 2" EASY-GUIDER	$189.50
2" EASY-GUIDER (Mamiya 645)	$239.50
2" Adapter for Pentax 6X7	$129.00
2" Adapter for Hasselblad	$229.00
2" Adapter for Bronica SQ-A	$175.00
2" Extension for viewing	$26.00

2" DELUXE BARLOW

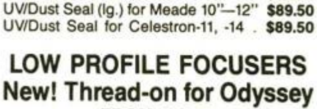
1.8x Multiplier Lens (2" Barlow)

LUMICON 1.8x Multiplier Lens (2" Barlow)	$259.00

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (925) 447-9570 FAX (925) 447-9589

LARGE UV/DUST SEAL



Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	$199.50
UV/Dust Deal for Celestron C-8	$39.00
UV/Dust Seal for Meade 4"—8"	$39.00
UV/Dust Seal (lg.) for Meade 10"—12"	$89.50
UV/Dust Seal for Celestron-11, -14	$89.50

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape!
Coulter Odyssey (thread-on installation), Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	$69.50
LUMICON 2" Helical Focuser 1½" high	$75.00
LUMICON Non-rotating Helical Focuser	$129.00
2" Astro Systems focuser, only 2" high	$139.00
3 handles for non-rotating focuser	$12.95
2"/1¼" adapter w/48mm filter threads	$20.00
2" LUMICON EASY-GUIDER	$189.50

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼" 50mm Finderscope **$69.50**, 45° version	$69.50
1¼" straight-thru 80mm SUPER-FINDER	$199.50
1¼" right-angle 80mm SUPER-FINDER	$209.50
1¼" right-angle version, w/star diagonal	$239.50
25mm Cross-hair 1¼" eyepiece (12X)	$59.00
Large mounting rings for 80mm Finder	$55.00
1¼" Star Diagonal **$49**, Mounting Brackets,	$39.50
1¼" 45° diagonal for correct left-right views	$49.00
1¼" 90° Amici diagonal, correct left-right view	$59.50

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	4/$2		
2" O.D. plug	2/$2	3½" O.D. plug	$1.50
1¼", 1⅜"	3/$2	7½"	$10
1½"	2/$2	9½", 10.4"*	$15
2"	2/$2	12½", 12⅞"*	$20
2⅛"	2/$2	15.0", 15.6", 16"*	$28
5½"	$6	19" (DS-16)	$35
*Fits Odyssey		21" (Odyssey-II)	$35

PRODUCTS

What's New at Tele Vue?

▶ Tele Vue Optics, a long-time designer and producer of high-end eyepieces and telescopes, has two new refractors and a new Executive Mount on the market.

The Tele Vue-101 is designed to meet the goals of superior quality with travel ease. It weighs only eleven pounds and mates well with Tele Vue's Gibraltar Mount and Sky Tour Computer. Adapters are also available to attach the telescope on an equatorial mount.

This new refractor's design is diffraction-limited and color corrected to a level beyond all of its predecessors. It uses special dispersion glass and hand-tuned lens spacing that is tested at 338x for final image correction. At f/5.4, the 101's fast, flat-field optics are well suited for telephoto, astrophoto, and CCD applications.

The refractor's construction includes powder-coated tubes in evergreen and ivory (pictured above), or you may choose solid brass (Renaissance-101). All major components are precision machined and black anodized, including the felt-lined sliding dew shield, screw-on lens cover, front lens cell, and 2" focusser housing. The one-piece machined aluminum 2" star diagonal and ¼" adapter have the added security of captive lock screws. The telescope also comes with a 20mm Tele Vue Plössl eyepiece and a fitted, foam-lined hard case, with cutouts for five eyepieces and Tele Vue's Starbeam finderscope.

Tele Vue Ranger Executive Mount

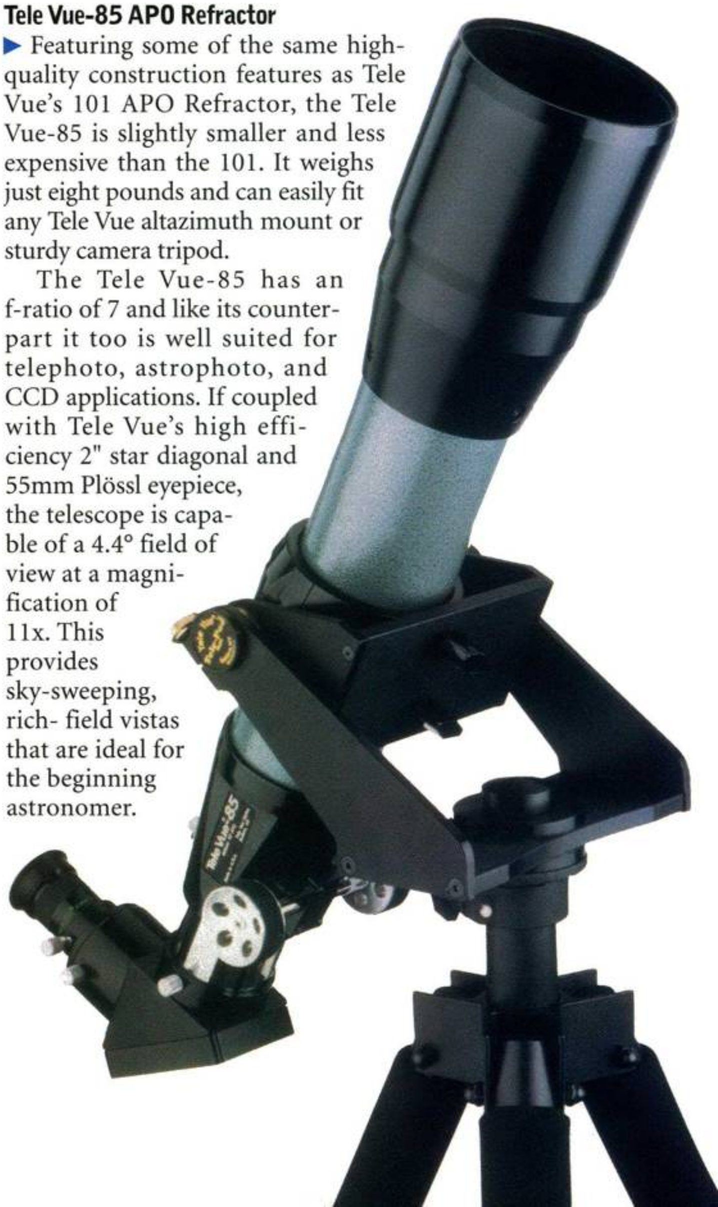
▶ This new, hand-rubbed, solid walnut altazimuth mount turns the solid brass Ranger refractor into a showpiece instrument suitable for home or office. The Executive Mount is designed to complement the Ranger in both form and function. Large solid brass knobs control vertical tension, while Teflon pads allow for smooth horizontal motion. For observing ease, a ¼–20 threaded insert in the base lets you mount the apparatus on to your camera tripod.

Tele Vue Optics, 100 Route 59, Suffern, NY 10901; phone, (914) 357-9522; website, http://www.televue.com. Tele Vue-101: $4,050, Tele Vue-85: $2,500, Ranger Executive Mount: $400.

Tele Vue-85 APO Refractor

▶ Featuring some of the same high-quality construction features as Tele Vue's 101 APO Refractor, the Tele Vue-85 is slightly smaller and less expensive than the 101. It weighs just eight pounds and can easily fit any Tele Vue altazimuth mount or sturdy camera tripod.

The Tele Vue-85 has an f-ratio of 7 and like its counterpart it too is well suited for telephoto, astrophoto, and CCD applications. If coupled with Tele Vue's high efficiency 2" star diagonal and 55mm Plössl eyepiece, the telescope is capable of a 4.4° field of view at a magnification of 11x. This provides sky-sweeping, rich-field vistas that are ideal for the beginning astronomer.



SkyView™ Deluxe

NEW!

EQ Series

Get more info at www.telescope.com

Improved Features, Enhanced Performance, Unrivalled Value.

Look What's Included!

- New heavy-duty SkyView Deluxe equatorial mount
- Built-in polar axis scope for quick, easy polar-alignment
- Achromatic 6x30 finder scope
- Two Plössl eyepieces (1.25")
- Moon filter
- Rigid gold-anodized aluminum tripod with accessory tray
- FREE *Where the Stars Are* CD-ROM (Win) An $89 value!

SkyView Deluxe 6" EQ Newtonian

Features a diffraction-limited 6" *parabolic* primary mirror — not a cheaper, lesser-performing spherical mirror like on many competing (and more expensive!) 6" Newtonians. The difference in image quality is obvious! Focal length 750mm (f/5). #9403

SkyView Deluxe 4.5" EQ Newtonian

An exquisite combination of form, function, and affordability for the intrepid stargazer. Focal length 900mm (f/7.9). #9402

SkyView Deluxe 90mm EQ Refractor

Exceptionally crisp, high-power views of the Moon, planets, and beyond! Multi-coated 90mm (3.5") glass achromatic objective lens. Focal length 1000mm (f/11.1). #9401

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$599
($49 S&H)

Compare our prices to other brands!

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90mm
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BOOKS

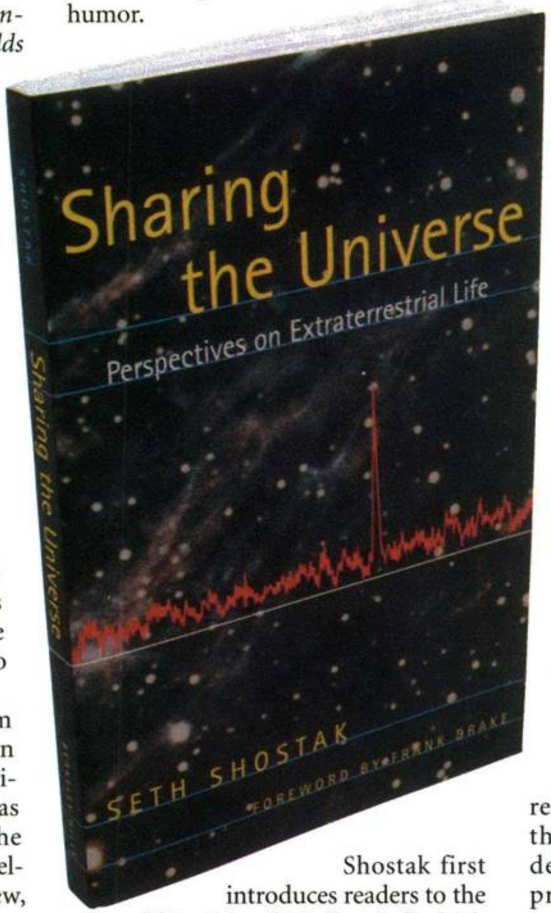
Sharing the Universe: Perspectives on Extraterrestrial Life

Seth Shostak, 202 pages, Berkeley Hills Books, Berkeley, 1998; ISBN 0-9653774-3-1; soft cover, $14.95.

▶ *E.T., Close Encounters of the Third Kind, Alien, Men in Black, Independence Day, Contact, War of the Worlds* ... the list could go on. Aliens visit us, attack us, befriend us. The big screen has produced hundreds of scenarios for us to gobble up, and we store them in our memories waiting for the time when a real alien will make itself known. As a result, we expect aliens to be like the ones we have seen on television or in the movies. Could there be truth in the fiction we have created?

In *Sharing the Universe: Perspectives on Extraterrestrial Life*, Seth Shostak attempts to answer this question. He takes the myth out of the movies and adds possible truths in ways that 20th century moviegoers can understand. Sometimes he leans too heavily on movie lingo, but the end result is a user-friendly guide to the extraterrestrial life debate.

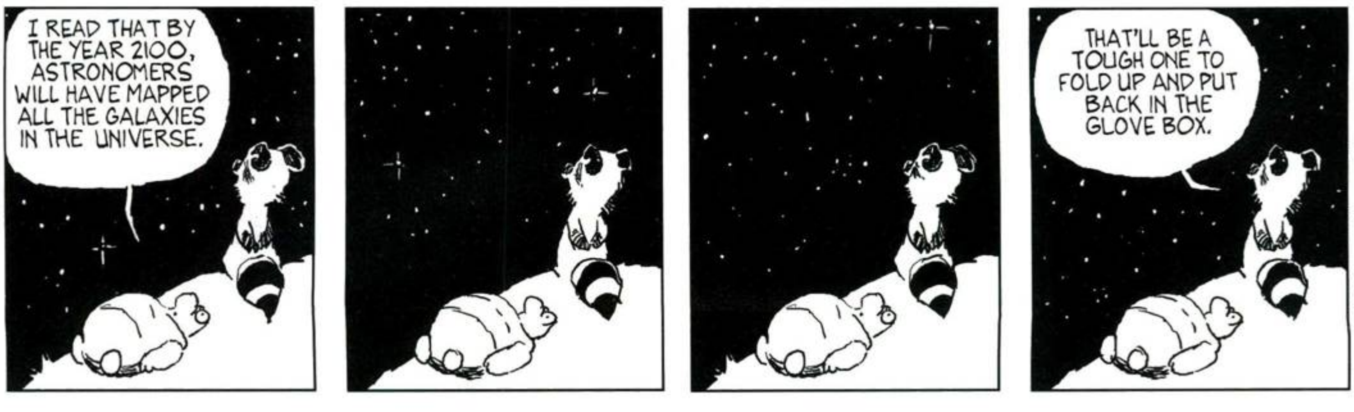
With a degree in physics from Princeton University, a Ph.D. in astronomy from the California Institute of Technology, and his work as the Public Programs Scientist at the SETI (Search for Extraterrestrial Intelligence) Institute in Mountain View, California, Shostak knows a little something about how the universe works. His work with SETI could lead some to assume he believes there is extraterrestrial intelligence out there somewhere. But readers are left unsure. Rather than forcing a predetermined opinion on his readers, Shostak takes them through a beginner's course on the universe and in the end leaves them with the tools to make their own decisions. He also delivers a detailed history of the SETI Institute interspersed with a fair amount of good-natured humor.



Shostak first introduces readers to the "Principle of Mediocrity," which proposes that nothing remarkable characterizes our cosmic situation. This is a fairly new idea from a world that until four centuries ago still believed Earth lay in the center of the universe. Since the realization by Copernicus that planets orbit the sun, discovery after discovery has moved us farther and farther from the center of the universe. Now we can rationally accept the reality that we are nothing out of the ordinary. "Our planet is but a small ball of rock around an ordinary star, one out of ten thousand billion stars in the universe."

In 1950, Enrico Fermi, the eminent physicist, recognized the paradox between the expectation of extraterrestrial life being common and the actual abscence of detecting it. He posed the question, "Where is everybody?" Why haven't they found us? The Fermi paradox has done more to promote searches for sentient beings than it has done to settle the issue. More theories than ever before, both technological and sociological, have been proposed as reasons why the aliens haven't made contact. It's as if no one wants to accept the fact they are simply not here.

There's an alternative that satisfies both camps. Shostak gives us the idea with a wry, humorous tone: Maybe they are already here. They left signs in our wheat fields. The government has kept them secret for years. Shostak recounts the history of the paranoia that was popular in the 1950s. He describes government studies disproving the existence of UFOs. He points out that nothing has been added to scientific knowledge over the years because of UFOs. Universities do not research this phenomenon, and scientists are not


I READ THAT BY THE YEAR 2100, ASTRONOMERS WILL HAVE MAPPED ALL THE GALAXIES IN THE UNIVERSE.
THAT'LL BE A TOUGH ONE TO FOLD UP AND PUT BACK IN THE GLOVE BOX.

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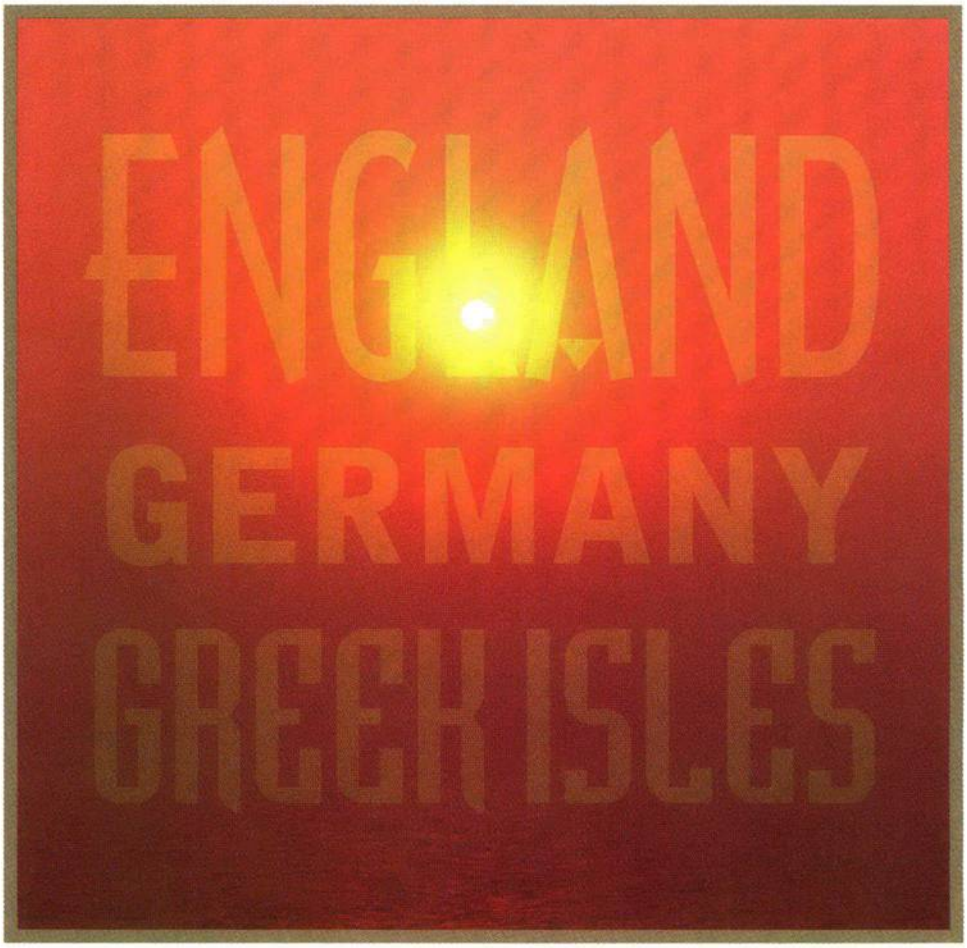
Astronomy Magazine presents

1999 solar eclipse tours



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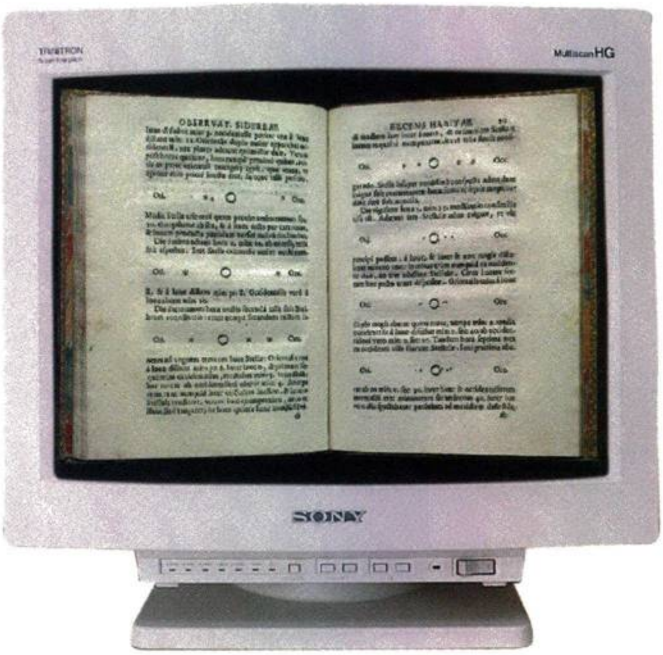
devoting their lives to catching flying wheat field artists in the act.

Intertwined with these ideas Shostak provides science lessons. He explains questions like, what kind of star system would be suitable for planets with life? A detailed description of stars from brown dwarfs to red giants follows. The characteristics and lifespans of stars of different masses are given and explained. Another question: Do nearby stars have planets? Until 1993 astronomers had not found any planets other than the nine in our solar system. Planets shine, like the moon, by reflected light, but not even the refurbished Hubble Telescope can resolve their reflected starlight. It wasn't until astronomers reverted to indirect methods, such as looking for stellar wobbles, that they began to find planet after planet in our galaxy.

Sharing the Universe doesn't take long to read. The historical side is informative and lays the groundwork for understanding the scientific aspects of the book. The book refreshingly deals with extraterrestrial life from a rational point of view. Shostak leaves readers gazing at the stars with greater understanding and with inspiring questions of possibilities. — *Rhonda Loveridge*



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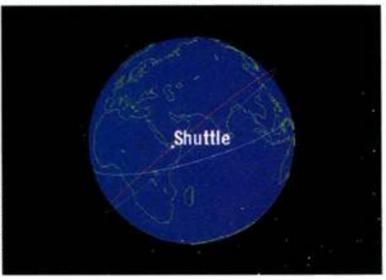

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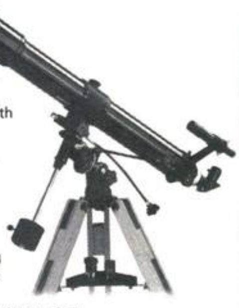

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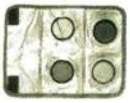

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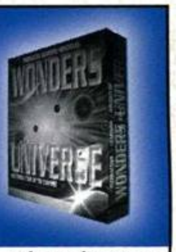

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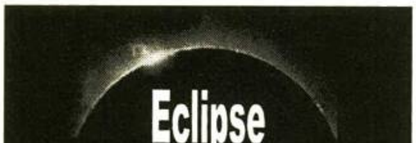

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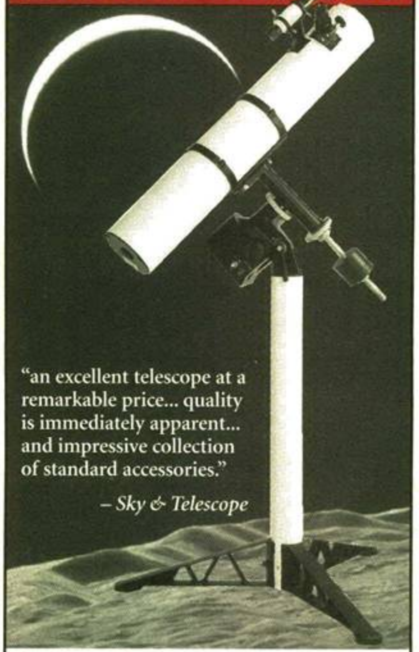

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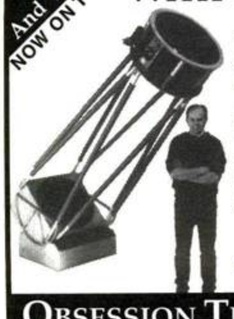

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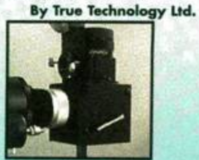

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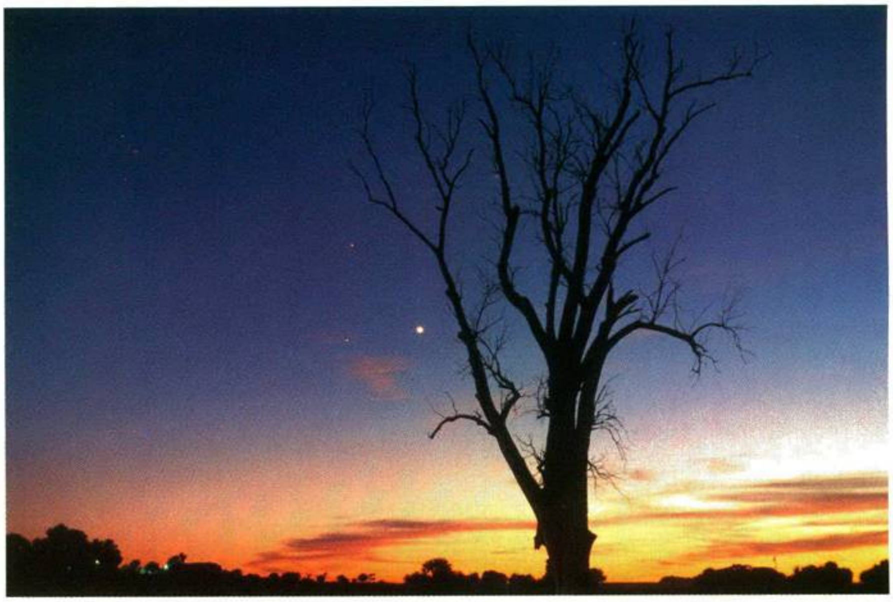
LOOKING AHEAD

FEBRUARY


Douglas C. Zubenel

Venus, Mars, and Antares glow through a winter tree's silhouette.

For those who have not heard, the **Winter Star Party** in the Florida Keys **has been cancelled** due to extensive damage to Camp Wesumkee by Hurricane Georges. See Event Horizon in the AstroNews column of this issue, and view the Southern Cross Astronomical Society's website, http://www.scas.org, for a full update. Watch for the return of the WSP in the year 2000 — it promises to be better than ever.

But all is not lost. Your plans for a mid-winter break in the Florida sunshine can be redirected north a couple hundred miles. The Chiefland Astronomy Village has come to the rescue and is offering an alternative star party to the WSP with the organization of the **Chiefland Star Party** taking place **February 14–21** in the northwest part of the state.

A two-hour drive from the Orlando airport, the Chiefland Astronomy Village has space for up to 3,000 visitors and is reported to have excellent observing conditions. Facilities are rustic. Camping on the observing field next to your telescope is the norm, though motels and restaurants are available in town.

Pre-registration is not required, but an RSVP would be appreciated so the planners will be able to estimate star party attendance.

For more information, contact the Chiefland Star Party, 5450 N. W. 52 Court, Chiefland, FL 32626; Tom and Jeannie Clark, (352) 490-9101; Jack and Alice Newton, e-mail, deepsky@svic.net; website, http://www.scas.org/chiefland.html.

JANUARY 26
Space Place Telescope Clinic

▶ U. W. Space Place, Madison, Wisconsin. 7 P.M. Contact Jim Lattis, (608) 263-4680; e-mail, lattis@sal.wisc.edu; website, http://www.sal.wisc.edu/SpacePlace/.

FEBRUARY 7–8
Northwoods Winter Starfest

▶ Hobbs Observatory, Beaver Creek Reserve, Fall Creek, Wisconsin. Sponsored by the Chippewa Valley Astronomical Society. Contact Ray Forsgren, 4856 Inlet Drive, Chippewa Falls, WI 54729; (715) 720-0226; e-mail, starman@discover-net.net; website, http://www.phys.uwec.edu/cvas/.

FEBRUARY 10–14
Orange Blossom Special Star Party

▶ Hickory Hill Observing Complex, Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club. Contact Dennis and Ellen Farr, 8811 West Broad Street, Tampa, FL 33615; (813) 884–9111; website, http://home1.gte.net/hoffmanc/index.html.

FEBRUARY 20
Wagman Winterfest

▶ Nicholas E. Wagman Observatory, Deer Lakes Park, Russellton, Pennsylvania. Free. Sponsored by the Amateur Astronomers Association of Pittsburgh. Contact Pete Zapadka, (412) 279-0627; e-mail, pzapadka@fyi.net; website, http://trfn.clpgh.org/orgs/aaap.

MARCH 6
AstroPhoto Seminar

▶ Moorpark College, Moorpark, California. A day-long seminar on all aspects of astrophotography. Sponsored by the Ventura County Astronomical Society. For registration information, contact Dave Holland, P. O. Box 982, Simi Valley, CA 93062; e-mail, Ravndave@ix.netcom.com.

MARCH 12–14
STARPAW99, Practical Astronomy Weekend

▶ Organized by the Andromeda, Astronomical Society Mol, Domein De Maat, Mol-Postel, Belgium. Registration deadline, February 19. Contact Josch Hambsch, Oude Bleken 12, B-2400 Mol, Telephone 32 (0) 14-310507; e-mail, hambsch@irmm.jrc.be.

MARCH 15–19
Lunar and Planetary Science Conference

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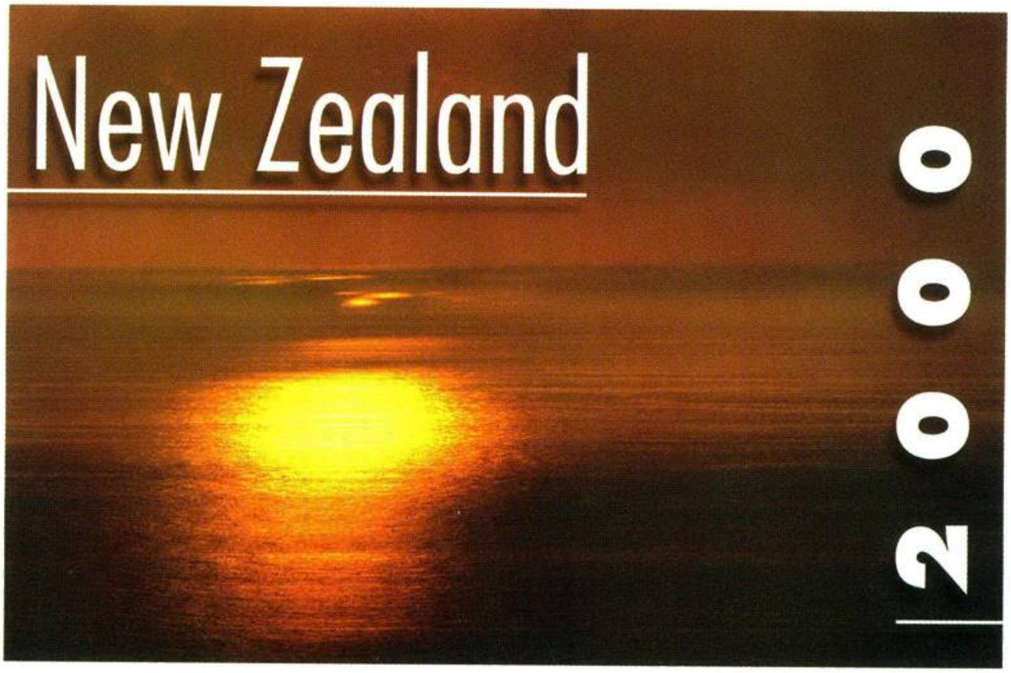

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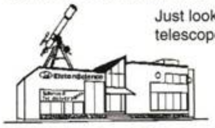

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Roland and Marjorie Christen

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More than two minutes of totality await those who venture to Europe or Asia for the August 11 solar eclipse.

A BAR FOR THE MILKY WAY
Our galaxy isn't the simple spiral we've thought all these years: New studies show it has a large bar running through its center.

A VERY LARGE TELESCOPE
Europe is building a huge telescope in Chile destined to be the world's largest.

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OBSERVING SURPRISES

The Shadow Knows

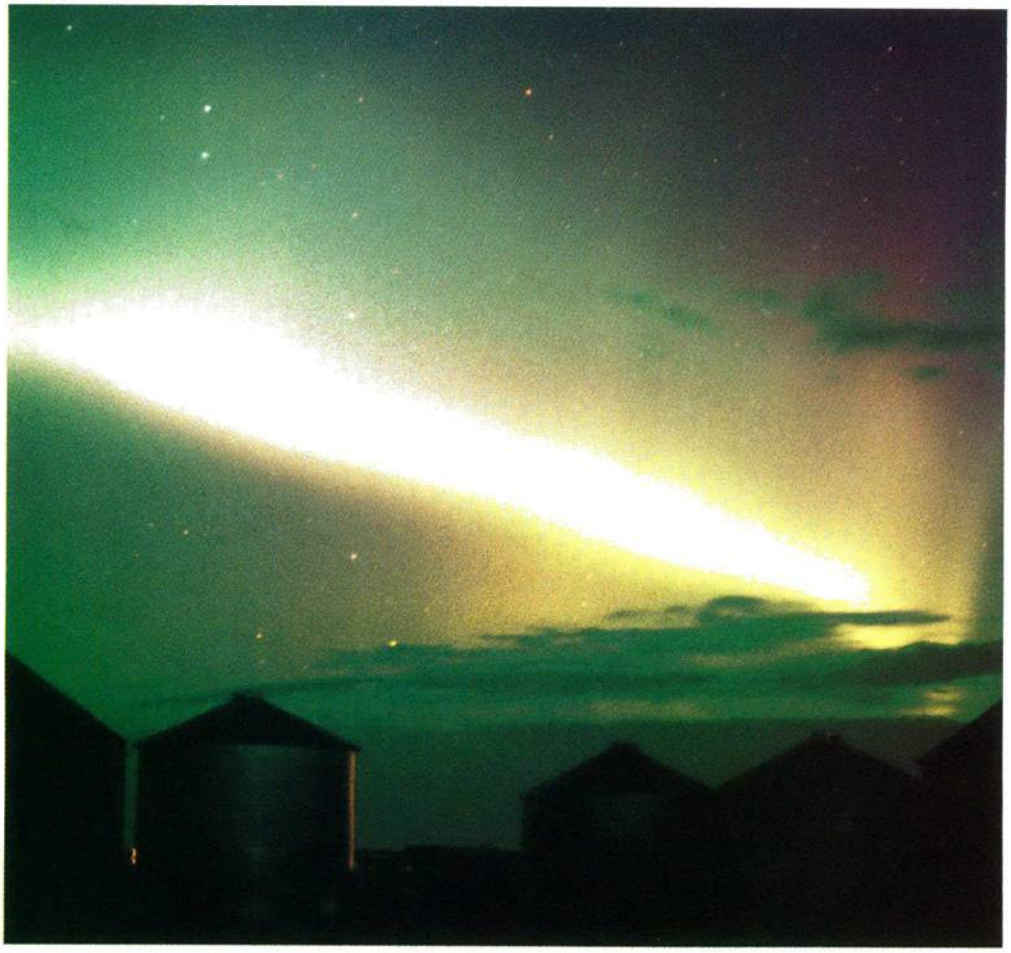
Watching the King of Planets can pay off with unexpected events.

Darkness was coming on like a rapid-fire case of stomach flu. It wasn't long before members of the Local Group of Deep Sky Observers started to set up for the evening's observing on August 22, 1998. Next came the heavy application of "vulture" repellent; Florida hosts some of the world's biggest mosquitoes.

Dave Gracey dug into his arsenal of goodies and produced not only five mosquito coils but some of the foulest smelling repellent I've ever been close to. After a typically beautiful Florida sunset we all sat around telling unbelievable observing stories waiting for the clouds, which had thickened, to dissipate.

After half an hour of darkness only a few of the most diehard observers had unlimbered their scopes, as most of us thought the night would only reveal periodic good stories under the clouds.

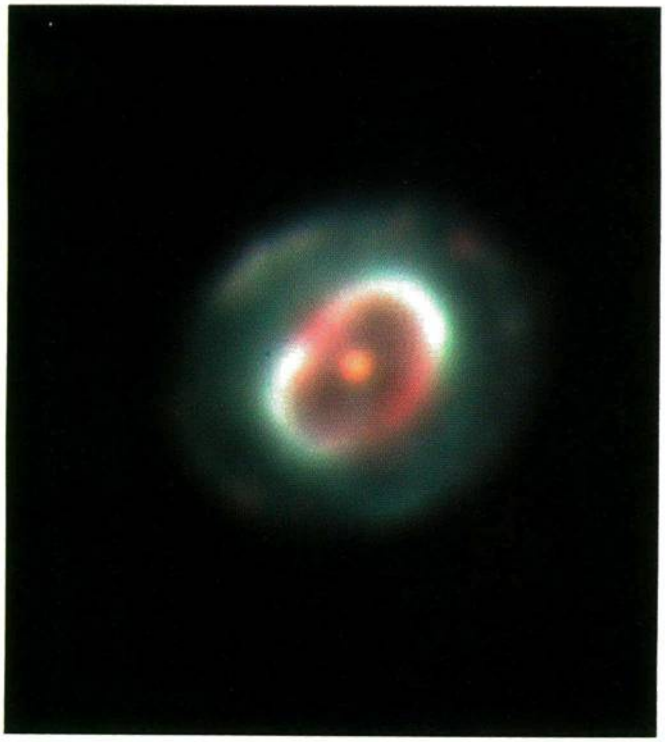
Then, suddenly, "Hey — there's the Summer Triangle!" Sure enough, stars were beginning to appear. Everyone scrambled to set up their telescopes, pull out binoculars, and grab maps. I dragged my 8-inch Dobsonian out of the truck to soak up some much needed starlight, unaware of the incredible surprise treat that awaited us.



Brilliant Aurora Gleams

JAY BRAUSCH

(50mm lens, Fuji film, taken August 22, 1998, from Glen Ullin, North Dakota)



Planetary Nebula NGC 7662

BRAD EHRHORN

(12½-inch Ritchey-Chrétien scope, ST-8 CCD camera)

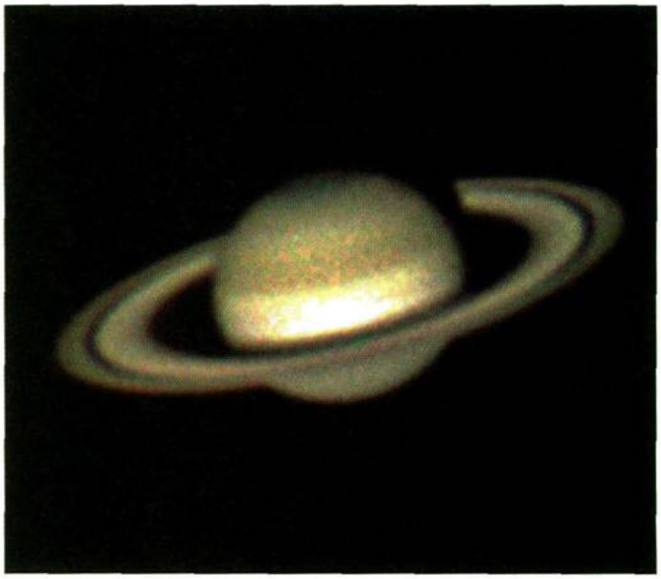
After peering into Sagittarius and Scorpius for a while, I started my regular walk of the observing field to see what others were up to. Dave, Bill Reinike, Steve and Susan Carroll, and Bill Jones were running back and forth between Dave's 6-inch reflector and Steve's 7-inch Dob checking out the Veil Nebula. Not being one to pass up a chance to gaze at the Veil, I awaited my turn in the small line.

In mid-gaze I overheard Rick Donnelly mention that Jupiter had cleared the trees and was looking pretty good. I asked for a quick peek in Rick's 8-inch Dob. This little speck of light never seems to let me down as there were at least five dark bands visible as well as three of the Galilean moons. Where was the fourth? Rick increased the magnification, which revealed a tiny "bump" on Jupiter's limb.

I moved over to my scope to watch what I hoped would be a transit of a moon's shadow across Jupiter. Sure enough, a tiny dark speck soon appeared on one of the dark bands. At about 11 P.M. I swung the scope back over to Jupiter again and noticed something rather odd — a second dark spot in Jupiter's northern hemisphere. It seemed too high up to be a second and simultaneous shadow crossing.

Could someone have missed another comet fragment making an impact on the planet, a new storm, some kind of amazing and unknown astronomical event that was unfolding before our privileged eyes?

The first shadow was like most I had seen before, a tiny dark spot that was crisp



Saturn's Rings

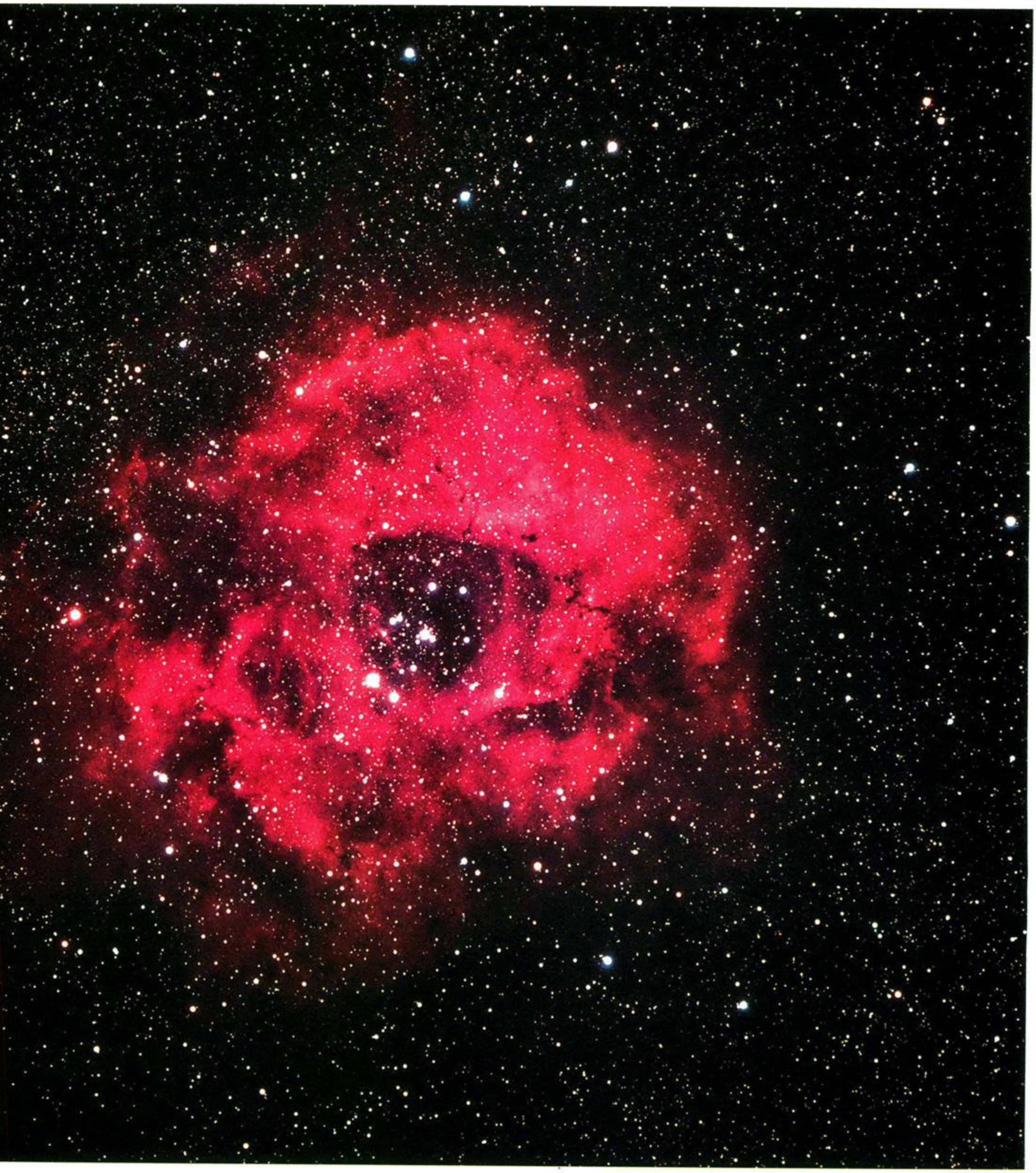
DAVID HANON

(7-inch f/9 refractor, ST-8 CCD camera, taken August 23, 1998)

Comet SOHO

KEN CHARLWOOD

(10-inch f/5.6 reflector, Fuji 800 film, taken May 22, 1998)



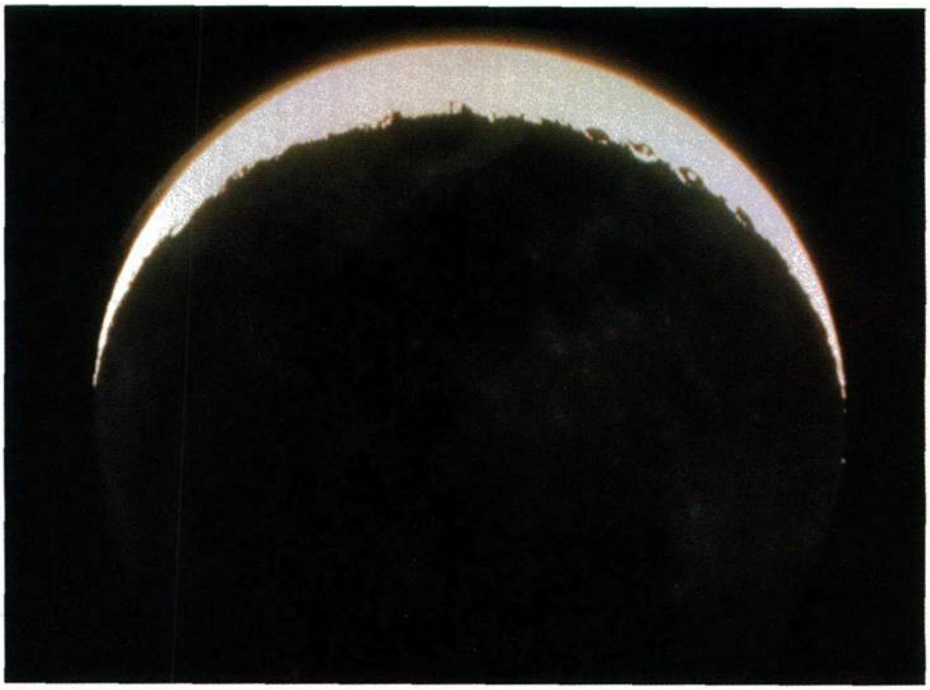
The Rosette Nebula (NGC 2237–9)

GEORGE GREANEY

(6-inch f/7 refractor, Fuji SHG 400 film, composite of two 50-minute exposures) around the edges. The second spot was larger, circular, and very crisp, and did not seem to retain its sharp-edged contrast as it neared the opposite side of the planet. It seemed the first shadow traversed Jupiter's face at almost twice the speed of the second. It was puzzling for a time before transforming into a most spectacular sight.

It wasn't until a few days later that we found out we had observed a rare double shadow transit of Io and Callisto that was visible in the eastern United States. It made for a memorable night, and one that should remind us all to keep a watch on Jupiter. ■

Scott Smith is an avid skywatcher living in Palmetto, Florida.



Earthshine on Luna

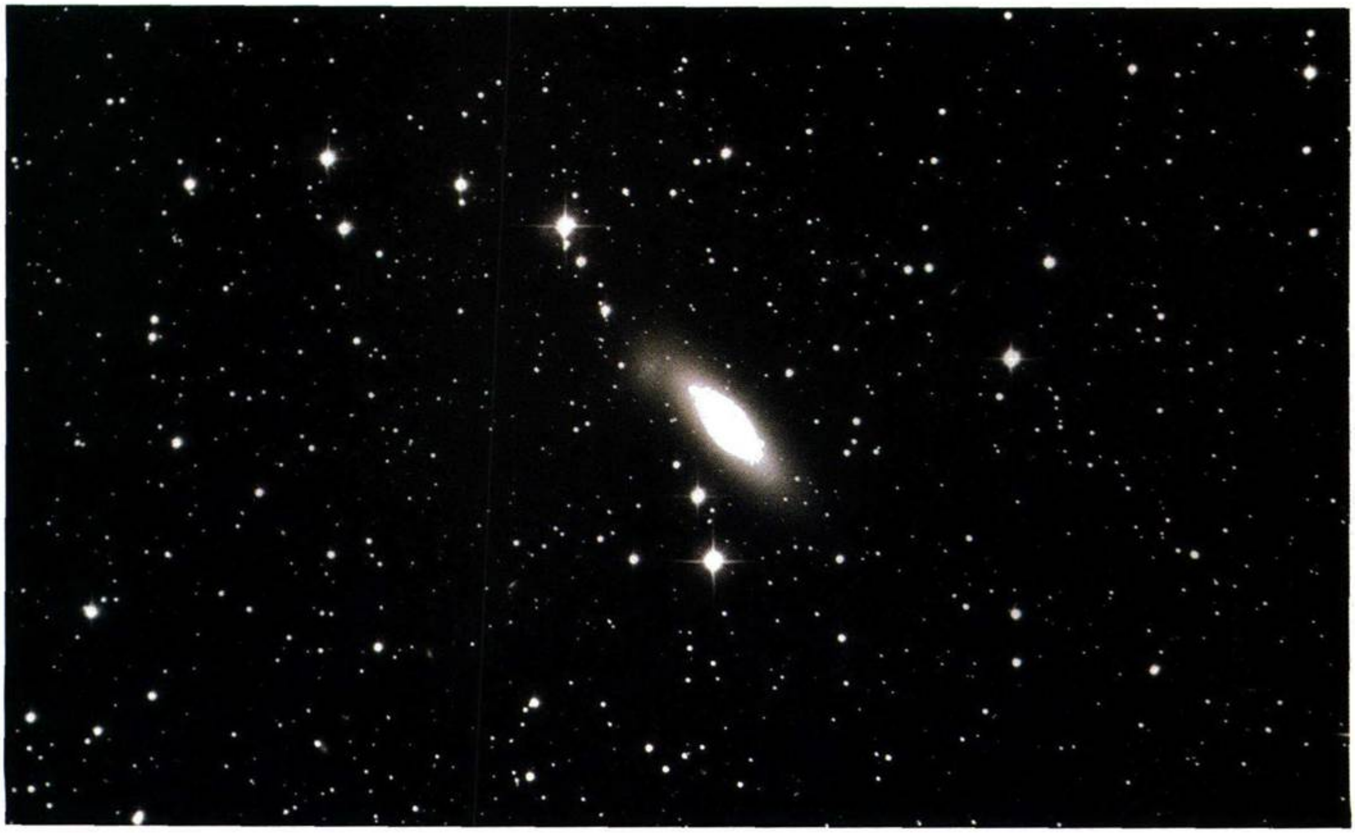
JEFF FOLKOWSKI

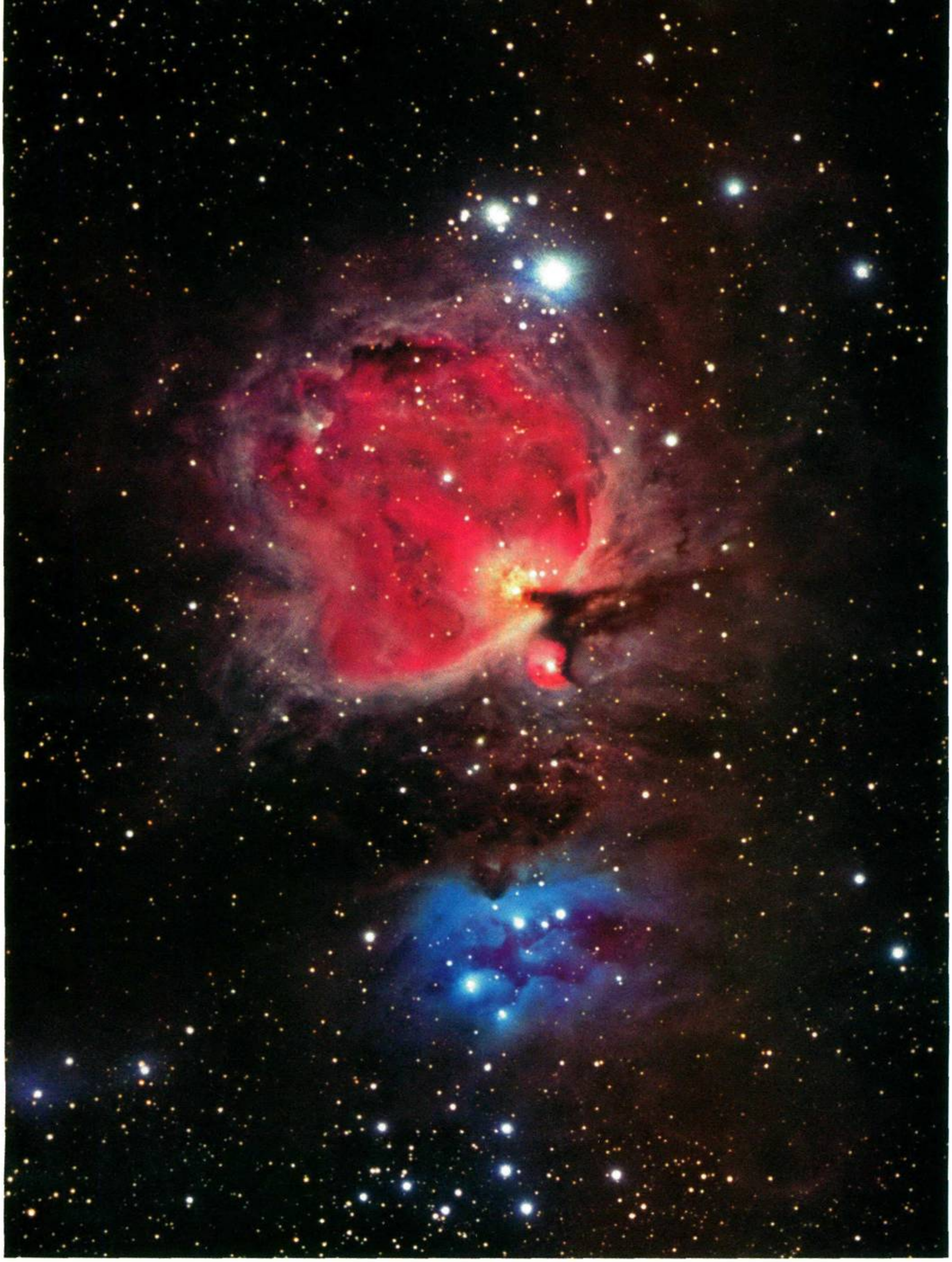
(8-inch SCT at f/10, Fuji Provia 400 film, 16-second exposure taken April 9, 1997)

Elliptical Galaxy NGC 1023 in Perseus

PRESTON SCOTT JUSTIS

(10-inch f/6 reflector, hypered Tech Pan film, 120-minute exposure)



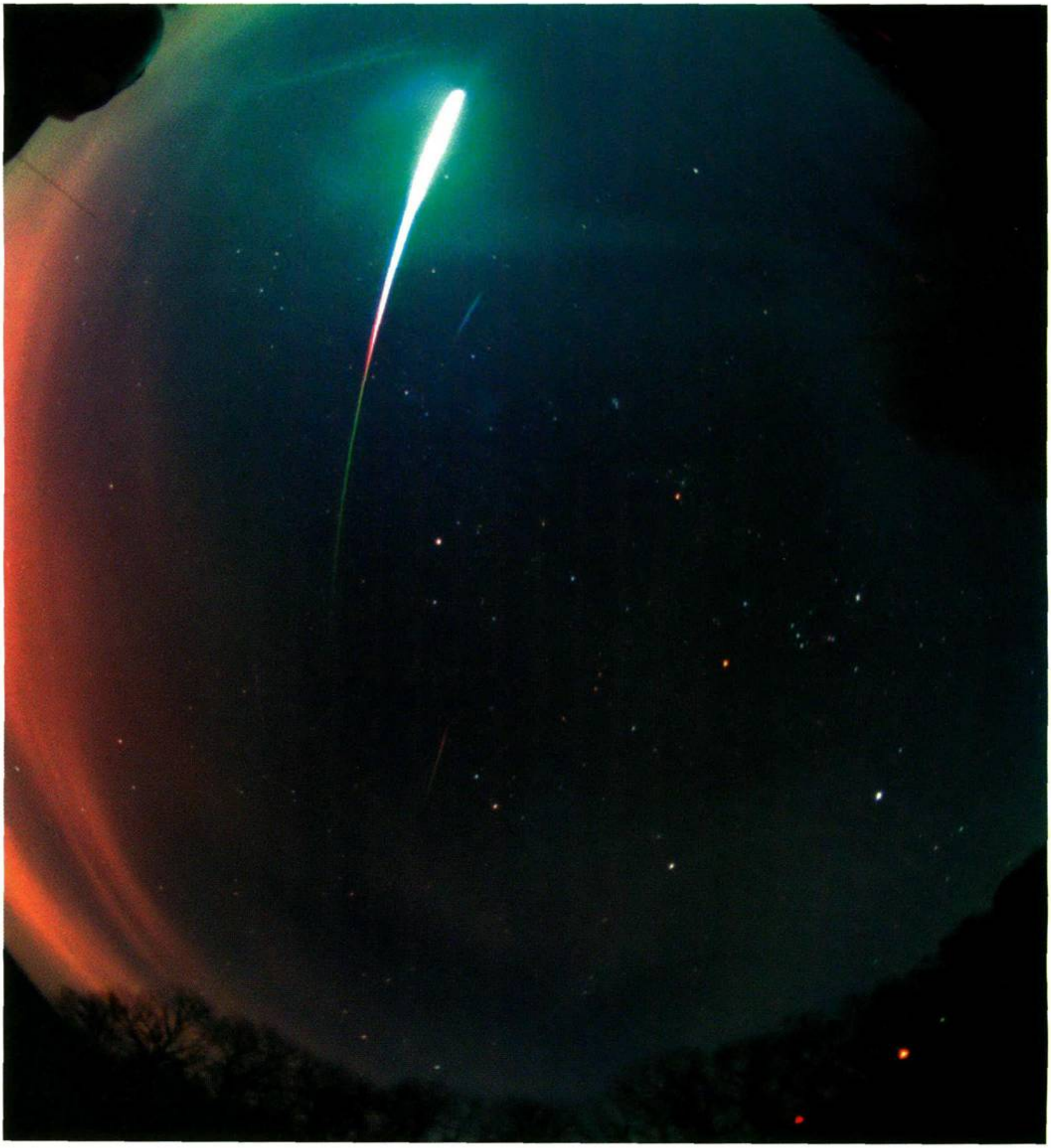


The Orion Nebula

TONY AND DAPHNE HALLAS

(7-inch f/7 refractor, Kodak medium format PPF film)

This month's best astrophoto



A Magnitude –12 Leonid Fireball Lights Up the Sky

VIC WINTER AND JENNIFER DUDLEY

(8mm fisheye lens, taken about 1:45 A.M. CST, November 17, 1998)

Observers hoping for a Leonid storm visible from the Powell Observatory near Louisburg, Kansas, got their wishes when meteors such as this one streaked overhead. Next month's issue will contain a full report on the Leonid shower.

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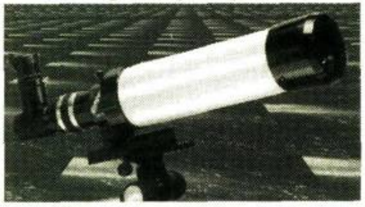

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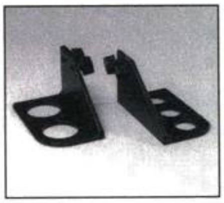
PANOPTIC

68° — aka “Nagler-lite”

Tack-sharpness and exceptional contrast fill your field! 68 deep sky degrees and fully multi-coated. 35, 27, 22, 19 & 15mm

NEW! EYEPIECE CADDY

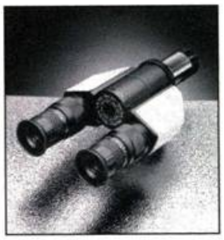
Eyepieces ride in Caddy Style



Don't chance your eyepieces rolling off a mount tray. Caddy 'em! So simple, so functional, so neat! The Eyepiece Caddy set holds 3, 1¼" and 2, 2" eyepieces at your fingertips. Fits the yoke arms of any Tele Vue Alt-Az head. Incl. 1¼" inserts for 2" holes.

NEW! BINO VUE

Twice is Nice for Newtonians



Bino Vue now has an optimized 2x, parfocal image amplifier for three times more field area. Great for all scope types. Bino Vue has no focus shift during inter-ocular adjustment, large multi-coated prisms and Tele Vue quality.

FINDER

Didn't Know She's Missing

Star-hop across the sky with Starbeam and Qwik-Point “red-dot” finders. Starbeam features a large 40mm lens, variable brightness, elegant design and all metal construction. Qwik-Point offers day & variable night brightness, light weight & exceptional value.

PLÖSSL

50°- Mr. P Would be Proud

Preferred Plössl in S&T comparison review. Fully multi-coated, patented Nagler design. 55, 40, 32, 25, 20, 15, 11, 8mm

NEW! TELE-POD

Earth & Sky Travel Tripod

This 7lb. tripod is for those on the go! Perfect for Pronto and Ranger. We've created a new yoke & cradle head with built-in azimuth bearing, and combined it with aluminum legs for a great mix of stability and portability. The Alt/Az head also fits any standard photo tripod.

24mm - 8mm ZoOOM

Not for the birds anymore!

Once solely considered as a birder accessory, the zoom permits an amateur astronomer to tune for optimal exit-pupil size (brightness vs power). Sharp 40° to 55° field, 20mm to 15mm of eye-relief and, of course, 100% Tele Vue quality control. Ideal power ranges with TVO scopes and 2.5x Powermate.

For the past 20 years Tele Vue has proudly offered quality astronomical equipment to amateur astronomers. Design revolutions: "Nagler" eyepieces, true Multi-Purpose telescopes and now Powermate to name a few, combine with exceptional quality control and knowledgeable service to create an ownership experience "...even better than you imagined."

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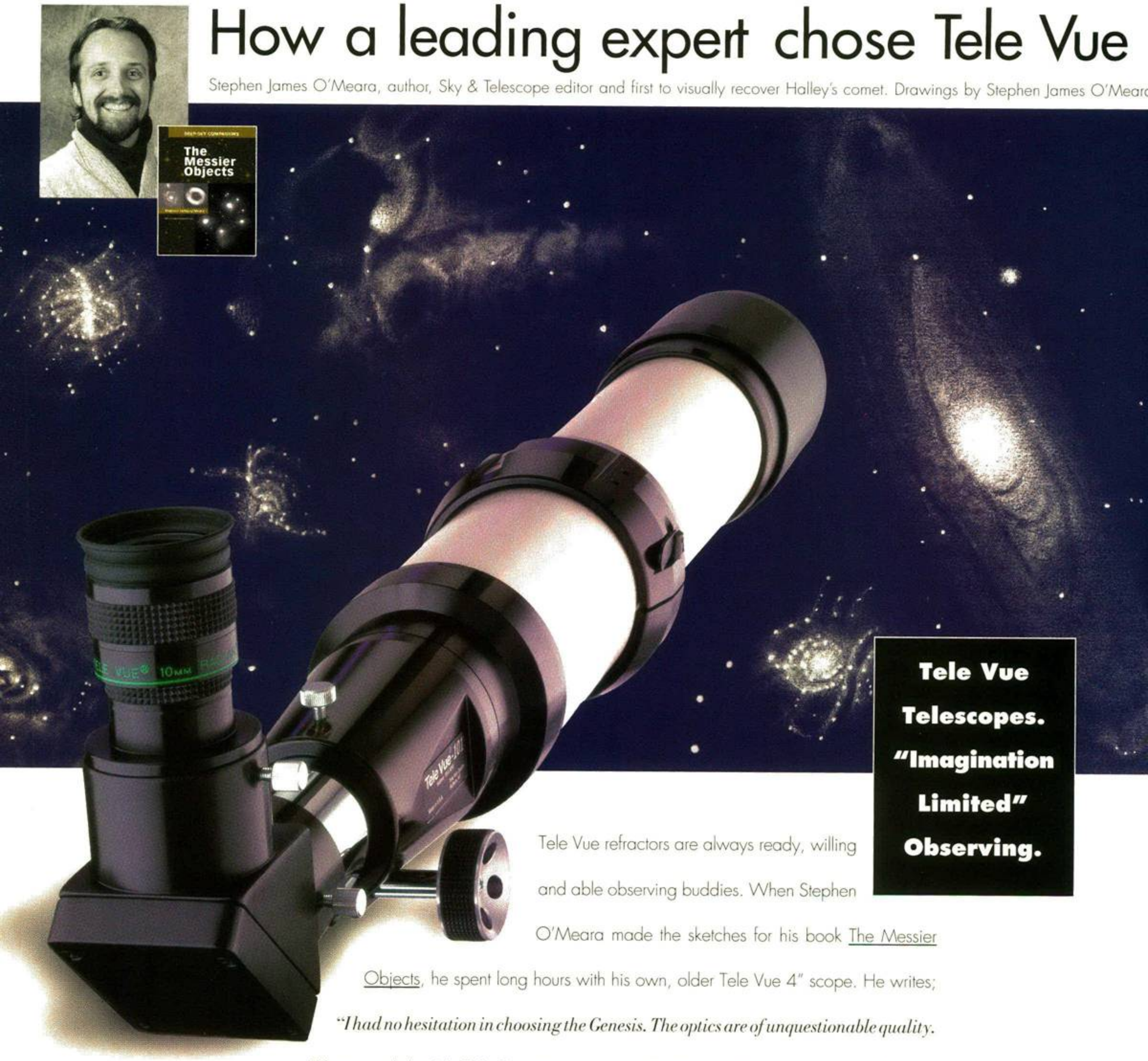
How a leading expert chose Tele Vue

Stephen James O'Meara, author, Sky & Telescope editor and first to visually recover Halley's comet. Drawings by Stephen James O'Meara



Tele Vue Telescopes. "Imagination Limited" Observing.

Tele Vue refractors are always ready, willing and able observing buddies. When Stephen O'Meara made the sketches for his book The Messier Objects, he spent long hours with his own, older Tele Vue 4" scope. He writes; *"I had no hesitation in choosing the Genesis. The optics are of unquestionable quality. When coupled with Tele Vue eyepieces (equally revolutionary designs), the Genesis transcends the traditional limitations of long-focus and rich-field refractors, combining the best qualities of both. Genesis and I met serendipitously under dark Texas skies, where I realized its quality and potential. The rest is history."* Stephen discovered a primary virtue of all Tele Vue scopes - versatile performance. Take one along for "imagination limited" observing.

Tele Vue 101: flat field APO, f/5.4

Tele Vue 85: APO, f/7.0

Pronto: 70mm ED, f/6.8

Ranger: 70mm ED, f/6.8

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Region of the Lagoon Nebula (M8) and Trifid Nebula (M20) in Sagittarius. Photograph by Jason Ware with the Meade 12" f/2.2 Schmidt Camera. A composite of two 17-minute, CCD-autoguided exposures on Kodak Ektar 25 film. The 2.3° x 2.3° area shown above represents less than one-fourth of the actual 4.3° x 5.4° sky area imaged by the Meade Schmidt Camera.

The largest-selling telescopes in the world.

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